CHEMICAL ENGINEERING PROGRESS

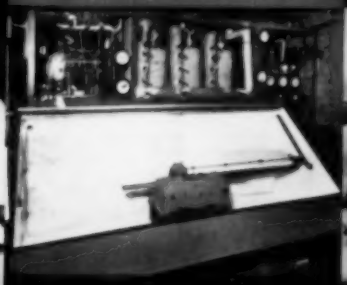
CEP

JULY 1957



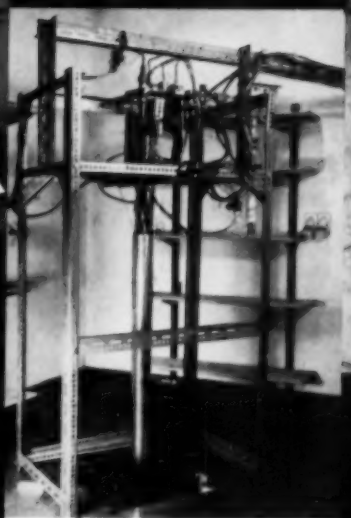
FILTER CAKES AND NONWOVEN MEDIA

New facts and formulas of value to the designer and process engineer are now available in easy-to-use form. Included are the new synthetic fiber nonwoven media, which offer many advantages.



DATA PROCESSING LINKS PLANTS

Diamond Alkali describes how they use computers plus a teletype network to compute and communicate business data to the right places. Once introduced into the system, it need not be recopied. Statistical summaries are produced effortlessly as byproducts. ALSO: DuPont describes how they have gone about adapting problems for computer feeding.



PILOT PLANT TAKES ON RADIATION

More petroleum refiners are setting up facilities to add radiation effects to their studies on petroleum processing. Gulf and Texaco are the most recent ones. SPECIAL: First pictures and description of the University of Michigan synthesis pilot plant. The business end is shown (above) over the well which houses the cobalt-60.

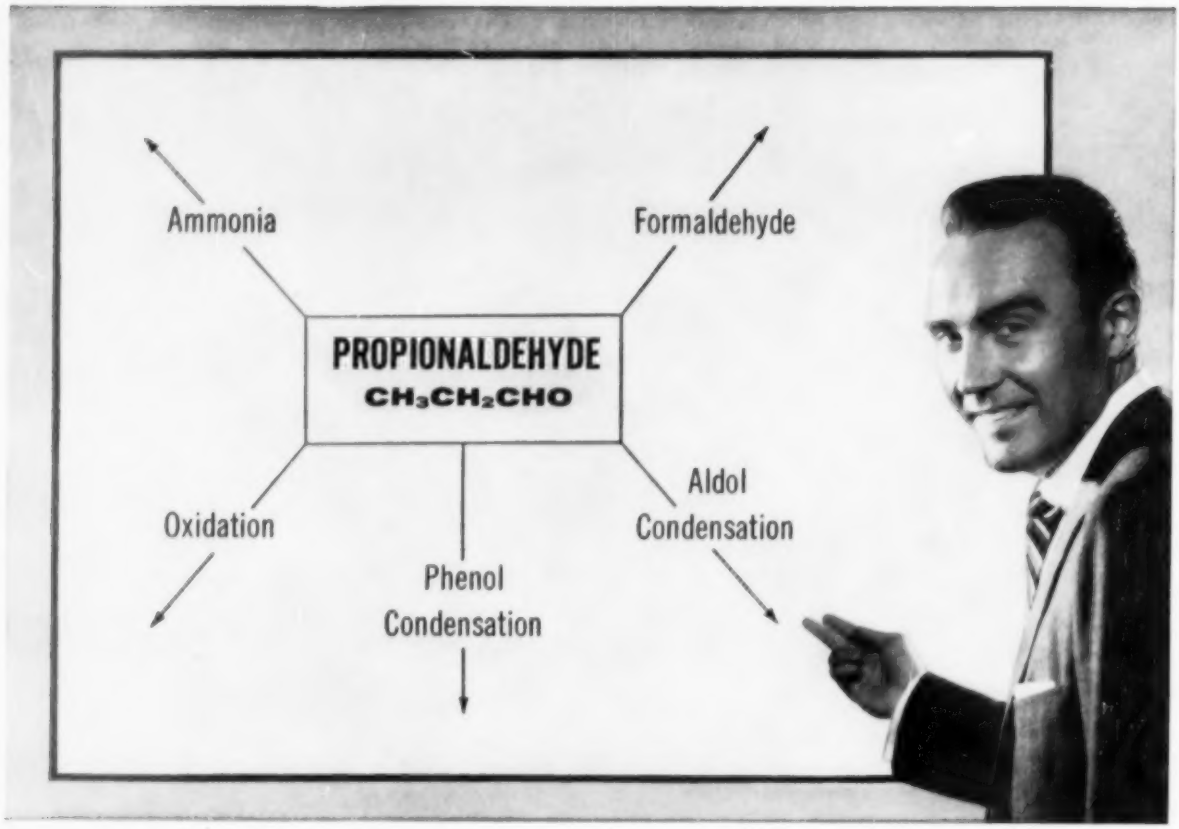


STAINLESS SOLVES PULP MILL CORROSION

Case study of how the development of rigid specifications, together with improvements in handling techniques, have reduced corrosion in an Alaskan pulp plant.

PLUS:

Young engineer • Teamwork in decision making • Spray dryer for product development studies • Materials at low temperatures II • Designing for nuclear safety • Which way to hydrogen • First U. S. low pressure polyethylene plant • Titanium from low grade ores • Test procedure for heat exchangers • Baltimore meeting program • Pyroceram—major material breakthrough



Propionaldehyde can help you develop new and improved products

(Now available in tank car quantities)

UNION CARBIDE

CHEMICALS

Union Carbide Chemicals Company
Division of Union Carbide Corporation
30 East 42nd Street, New York 17, N. Y.

Propionaldehyde offers you a versatile and economical route to new and better products for industry. A product of CARBIDE's oxo unit at Texas City, Texas, it is produced with consistently high quality.

These reaction products of propionaldehyde have already reached commercial importance—trimethylol ethane for alkyd and polyester resins; 2-methyl-1-pentanol for plasticizers; propionic acid for esters, salts, and cellulose ester molding powders; and propyl amines as rubber accelerators.

Other derivatives of propionaldehyde are intermediates for the manufacture of pharmaceuticals and lubricant additives.

Call or write now for a sample and complete information on propionaldehyde. In Canada: Carbide Chemicals Company, Division of Union Carbide Canada Limited, Montreal.

Chemical Engineering Progress

what's in this issue

July, 1957 • Volume 53, No. 7

Capital idea / 8
Letter to Editor—Reader advocates better magazine recognition of chemical-engineering-related activities in Nation's Capital.

Young engineer and his job / 12
Noted & Quoted—Advice given recently to young chemical engineers by retired oil industry executive *V. L. Shipp.*

Teamwork in decision making / 19
Richard W. Wallen—Factors contributing to possible failures on the part of teams to solve problems creatively, with emphasis on dealing with such potentially-suppressive factors as prestige.

Today's energy sources . . . tomorrow's engineering problems / 30
Noted & Quoted—Commentaries by prominent technologists *Monroe E. Spaght* and *Clifford C. Furnas.*

Pilot plants, models, & scale-up / 38
Marginal Notes—The drift away from pilot plant trials may be reversed through the use of small and easily made models, together with statistical theory.

Big game hunt / 49
Trends—Recent supreme court action against Du Pont for GM stock holdings seen as prelude to campaign against oil companies.

IGY / 311
Opinion & Comment—The International Geophysical Year has interesting connotations for chemical engineers.

CEP SPECIAL FEATURE
Filtration

Non-woven filter media / 313
Arthur C. Wrotnowski—Rapidly growing availability of non-woven fabrics, many including new synthetic fibers, makes these descriptions and data pertinent.

Moisture correlation of rotary filter cakes / 320
P. Nelson & D. A. Dahlstrom—New method for predicting the full-scale cake moisture contents from pilot plant data.

Porosity in filter cakes / 328
F. B. Hutto, Jr.—Series photographs show progressive decrease of porosity from liquid face of cake inward.

(Continued on page 5)

departmental features

Letters to the editor / 8 • Noted and quoted / 8, 12, 30 • Marginal notes / 38 • About our authors / 40 • Opinion and comment / 311 • Data service / 65 • Future meetings / 114 • News from local sections / 134 • CEP camera / 140 • Candidates for membership / 142 • People / 144 • Classified / 149 • News and notes of A.I.Ch.E. / 156

MODEL "M" BAR-NUN
ROTARY SIFTER



FEATURES
- Stainless Steel product zone.
- Big Capacity—up to 40 sq. ft. of screen area in floor space 3½ ft. square.
- Complete Rotary Motion—rapid, accurate separations.
- Totally Enclosed—dust-tight.
- All-Mechanical, heavy-duty drive and base.

In some plants, installation of a modern Bar-Nun has multiplied screening capacity in the same floor space. And, every inch of screen surface is active and productive. The Bar-Nun's single plane, uniform rotary motion rapidly exposes the material to a maximum number of screen openings.

The sifter box (stainless steel panels mounted on cast aluminum frames) totally encloses the screens, for dust-tight operation. Screens are easily removed for cleaning. Rugged all-mechanical construction and accurate counterbalancing assure smooth, trouble-free performance—and durability.

When you want top screening efficiency . . . economy . . . durability, you want the Model "M" Bar-Nun Rotary Sifter. Available with from 2 to 78 square feet of screen surface, for single or multiple separations. Write for Bulletin 505.

Recommendations and Engineering Service without Obligation

FEEDING · MIXING · SIFTING · WEIGHING · PACKING EQUIPMENT FOR THE PROCESS INDUSTRIES
B. F. GUMP CO.
Engineers & Manufacturers Since 1872
1311 S. Cicero Avenue • Chicago 50, Illinois

CLEAN* SEPARATION

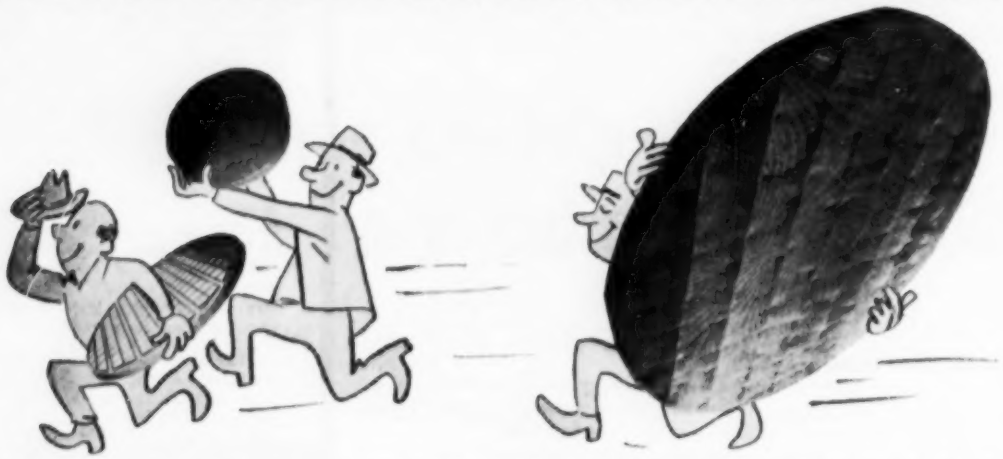
*99.9% plus with YORKMESH DEMISTERS (Mist Eliminators — Entrainment Separators)



YOU present your problems...



YORK will recommend and deliver the answer!



Why not take advantage of our vast experience in improving the performance of process equipment. In the past 10 years, the outstanding success of thousands of installations is proof of the superiority of YORKMESH DEMISTERS for entrainment control.

Yorkmesh Demisters are used to improve product quality, to avoid losses, and to increase thruput capacity. Our engineers will give careful consideration to the information you submit and will recommend the best answer to your problem.

YORKMESH DEMISTERS *improve the performance of:* **Vacuum Towers • Distillation Equipment • Gas Absorbers • Scrubbers • Evaporators • Knock-out Drums • Steam Drums**

OTTO H. YORK CO., INC.

8 CENTRAL AVENUE • WEST ORANGE, NEW JERSEY

YORK

Specialists in FLUIDS SEPARATION / ENGINEERS and MANUFACTURERS

CEP

what's in this issue

Publisher
F. J. Van Antwerpen

Editor
J. B. Mellecker

Managing Editor
W. E. Anderson

EDITORIAL STAFF

Associate Editors
H. R. Glennon W. B. Hoffman
D. J. Lynds

Editorial Assistants
H. Pitts M. Z. d'Angelo

Layout and Design
M. Wynne, Art Director
N. Howard, Assistant

Advisory Board

W. E. Alexander	A. W. Fisher, Jr.
T. J. Carron	O. E. Holbrook
E. B. Chiswell	George Jenkins
J. T. Costigan	K. N. Kettenring
L. J. Coulthurst	W. D. Staley
D. A. Dahlstrom	L. H. Stephens
James Donovan	N. C. Updegraff

BUSINESS STAFF

Advertising Manager
L. T. Dupree

J. M. Goode, Asst. Adv. Mgr.
J. M. Buchanan, Production Manager
E. Adelhardt, Production Assistant

Advertising Offices

New York 36—Paul A. Jolcuvar, Dist. Mgr.; Donald J. Stroop, Dist. Mgr.; Hale H. Carey, Dist. Mgr.; 25 W. 45th St., Columbus 5-7330.

Chicago 11—Richard R. Quinn, Dist. Mgr., 612 N. Michigan Ave., Room 507, Superior 7-0385.

Cleveland 15—Eugene B. Pritchard, Dist. Mgr., 1836 Euclid Ave., Superior 1-3315.

Pasadena 1—Richard P. McKey, Dist. Mgr., 465 E. Union St., Ryan 1-8779.

Dallas 28—Richard E. Hoierman, Dist. Mgr., 2831 El Capitan Drive, DA 7-3630.

Birmingham 9—Fred W. Smith, Dist. Mgr., 1201 Forest View Lane, Vesthaven, Tremont 1-5762.

Published monthly by American Institute of Chemical Engineers at 15 North Seventh Street, Philadelphia 6, Pennsylvania. Editorial and Advertising Offices, 25 West 45th Street, New York 36, N. Y. Communications should be sent to the Editor. Statements and opinions in *Chemical Engineering Progress* are those of the contributors, and the American Institute of Chemical Engineers assumes no responsibility for them. Subscriptions: U. S. and possessions, one year $6.00; two years $10.00 (Applies to U. S. and possessions only). Canada, $6.50; Pan American Union, $7.50; Other Foreign, $8.00. Single copies of *Chemical Engineering Progress* older than one year cost $1.00 a copy; others are 75 cents. Entered as second class matter December 9, 1946, at the Post Office at Philadelphia, Pennsylvania, under Act of August 24, 1912. Copyright 1957 by American Institute of Chemical Engineers. Member of Audit Bureau of Circulations. *Chemical Engineering Progress* is indexed regularly by Engineering Index, Inc.

Cover by Milton Wynne Associates

(Continued from page 3)

Computers in management cost accounting / 333
R. L. Hershey & C. R. Schwartz—Brief look is given at a Du Pont plant cost accounting calculation.

Integrated data processing—sound foundation for commercial operations / 338
Wm. A. Crichley—IDP serves Diamond's network of plants, provides system into which all sales and production documents and data are semi-automatically handled and analyzed.

Properties of materials at low temperatures, Part 2 / 342
R. J. Corruccini—Second part of low temperature correlations and derivations intended particularly for chemical engineers.

Spray dryer for product development studies / 347
E. J. Crosby & W. R. Marshall, Jr.—Described is an experimental unit designed for studying properties of spray-dried materials.

Combatting corrosion in pulp mill with stainless / 353
Joseph Kolberg—Case history of how an Alaskan pulp mill better realized the advantages of stainless steel.

Nuclear safety in reprocessing plant design / 357
Norman Ketzlach—Equipment and layout geometry are covered, with data, for those interested in entering into fuel reprocessing.

Which way to hydrogen? / 361
A. G. Eickmeyer—The demand for hydrogen is rapidly increasing. An evaluated review of present hydrogen production methods aids deciding which process to employ.

What's doing in indutsry / 52, 58
Wyandotte, Diamond expansions in chlor-caustic facilities focuses attention on balanced use of diaphragm-mercury cells . . . Largest oxygen plant . . . First low pressure polyethylene plant on stream by Hercules.

Pyroceram—wonder construction material here today? / 80
Corning's crystalline glass-like material looked into from a chemical industry viewpoint.

New titanium process uses low-grade ore / 94
Armour's new process produces titanium tetrachloride from ilmenite, may lower cost of vital metal.

Baltimore meeting program / 105
J. R. Mecredy, W. K. O'Loughlin, and Samuel C. Streep—All the good things about historic Maryland combine with an outstanding technical program to make attending a must!

Radiation seen as important processing aid / 118
Two more petroleum companies build radiation facilities, University of Michigan releases description of their work.

Guide to heat exchanger testing / 130
New A.I.Ch.E.-sponsored procedure expected to be basis for user-vendor shell and tube heat exchanger acceptance tests.

Will computers replace the chemical engineer? / 134
"No!" says panel at Southern California meeting of members of the profession.

Committee roundup—II / 156
A review of what Institute committees are undertaking.

HARSHAW

Tellerette

A NEW POLYETHYLENE TOWER PACKING BASED ON THE PRINCIPLE OF INTERSTITIAL HOLDUP

Increased Efficiency

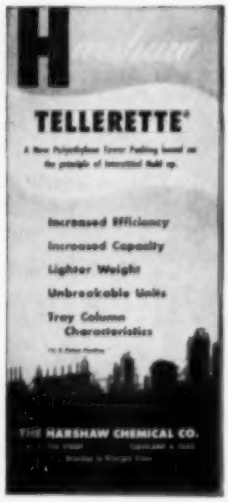
Increased Capacity

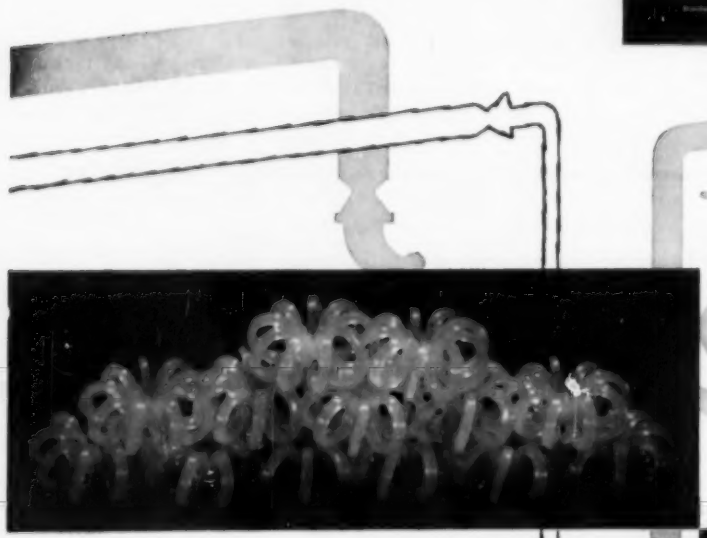
Lighter Weight

Unbreakable Units

Tray Column Characteristics

Send for this folder. It contains more detailed explanation.



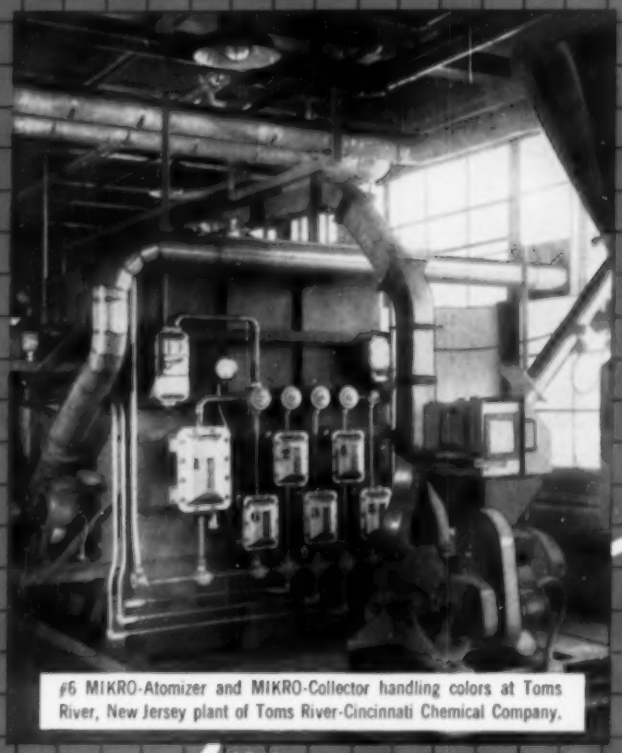




THE HARSHAW CHEMICAL CO.

1945 E. 97th Street Cleveland 6, Ohio

29 YEARS OF MIKRO-D SERVICE AT TOMS RIVER-CINCINNATI CHEMICAL CORPORATION*



#6 MIKRO-Atomizer and MIKRO-Collector handling colors at Toms River, New Jersey plant of Toms River-Cincinnati Chemical Company.

1928 1930 1935 1945 1950 1951 1953 1957

● The history of equipment purchases at Toms River-Cincinnati Chemical Corporation offers an outstanding example of time-tested satisfaction with MIKRO-D Pulverizing and Dust-Collecting equipment. Since 1928, the number of installations in their various plants has increased almost step-by-step with the steady growth of this foremost chemical firm. Today, you'll find a roster of MIKRO-D equipment ranging from laboratory-sized units to mills that process tons per hour of dyes and dyestuff materials, every hour of the day.

We'll gladly make recommendations regarding the product you are grinding. Send us a sample and specifications. You'll discover how MIKRO-D—now serving chemical processing plants throughout the world—can insure a more profitable operation, and a product that meets the highest standards of quality.

* Since 1928, over 30 pieces of MIKRO-D Equipment were installed in the Norwood, Ohio and St. Bernard, Ohio plants, and in the Toms River, New Jersey plant, of the Toms River-Cincinnati Chemical Corporation. The equipment includes MIKRO-Sampimills, Bantam MIKRO-Pulverizers, No. 1, 2 and No. 3 MIKRO-Pulverizers, and No. 6 MIKRO-Atomizers and MIKRO-Collectors.

Mikro-D PULVERIZING MACHINERY DIVISION

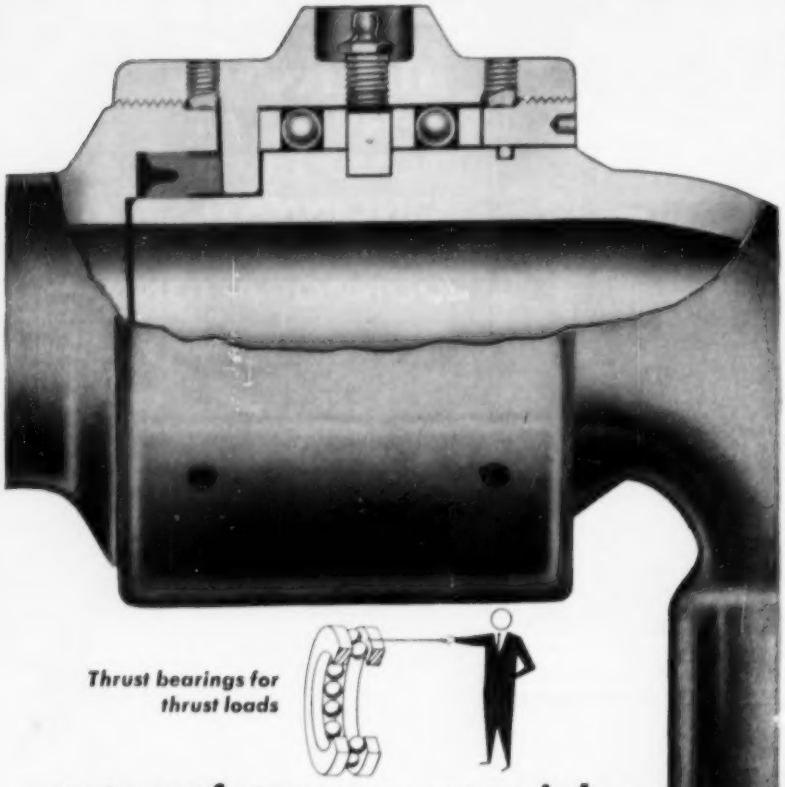
METALS DISINTEGRATING COMPANY, INC.

32 Chatham Road • Summit, New Jersey

Genuine Mikro-D Replacement Parts available from large stock within 48 hours.

Manufacturers of Pulverizing, Air Conveying and Dust Collection Equipment

FINEST SWIVEL JOINT ON THE MARKET TODAY



Thrust bearings for thrust loads

out-performs on every job — yet costs no more



Grooved packing for high temperatures or corrosive services.



Lip type packing for high pressures.

Throughout the world you'll find Continental-Emsco Ball Bearing Swivel Joints on vital installations where safety, free-turning and low resistance to flow are essential.

Compare Continental-Emsco ball race design — thrust bearings for thrust loads. Compare the method of sealing against leakage — an isolated packing chamber in which is retained the type of packing most suited to the job. Joint breaks like a union for easy inspection or replacement of packing.

You profit directly from these features — the result of years of engineering know-how built into every Continental-Emsco joint. If you're not already using Continental-Emsco, better send today for latest catalog and prices.

CONTINENTAL-EMSCO

Serving the Oil and Gas Industries ... Worldwide

CONTINENTAL-EMSCO COMPANY

A Division of The Youngstown Sheet and Tube Company

P.O. Box 3098, Terminal Annex, LOS ANGELES 54, CALIF.

HOUSTON, TEXAS DALLAS, TEXAS CHICAGO, ILL.

Export Representative, R. J. Enke & Associates, Inc.
10 Columbus Circle, New York 19, N.Y.

Letters to the editor

A "Capital" Idea

The Washington scene is an amazingly active one as far as developments and events of significance to the chemical engineering profession is concerned. Yet, in spite of the reams of material published about Washington goings-on, I (and many of my associates) are convinced that the reporting and analysis of the more significant of these events for the chemical engineer are lacking.

I have discussed this problem with several chemical engineers as well as with people in various government agencies engaged in activities of interest to chemical engineers and I believe there is much enthusiasm for getting some greater flow of representation (both news and interpretation) of the chemical engineering activities in the nation's capital before the members of the profession.

I strongly urge that careful consideration be given this problem, with a view to embodying in *Chemical Engineering Progress* a representative service covering the Washington picture.

J. L. Gillman, Jr.
Washington, D. C.

Noted and quoted

Genius, Anyone?

. . . Those who believe that science is a system of specialisms for specialists alone, and that experiment is self-sufficient, will repudiate the modest suggestion I have to make as redundant and irrelevant. But . . . where little can be done it is all the more necessary to do the little that is possible. We cannot produce genius at will, but if it is there we can provoke it . . .

. . . Let there be put on each faculty notice board at the opening of the academic year a statement of ten unsolved fundamental problems lying in the broad field of each group of faculties. Let these problems be proclaimed and explained at special inter-faculty meetings of research students attended by all the teaching staff. And let these problems be collected in a master *Book of Problems*, lying open to all on the Reference Desk of every scientific library. . . . From the millions of students we can thus create an invisible college of fundamental research. . . .

Lancelot Law Whyte
"Can We Grow Geniuses in Science?"
Harpers Magazine



When Specs Demand Job Matched Piping and Fittings One Call Will Do it All—B&W

The layout has been made. Erection schedules are in the planning stage. What you do now in contacting a source of supply for your alloy steel pipe fittings and flanges, can very well be one of your most important moves.

If you call on B&W, you can be assured of benefits that simplify scheduling problems. With one call to B&W—on one order—you can obtain matched pipe, fittings and flanges to meet your specific requirements. What's more—the delivery of the alloy steel pipe, the seamless welding fittings, and the forged steel flanges that make up the integrated system you desire—can be coordinated. This is just one more reason why B&W has earned the reputation and acceptance as "the natural source" for alloy pipe and fittings.

Call on Mr. Tubes at your nearby B&W Tubular Products Division District Sales Office—let him coordinate your alloy steel pipe, seamless welding fittings and forged steel flange problems. He can help you. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.



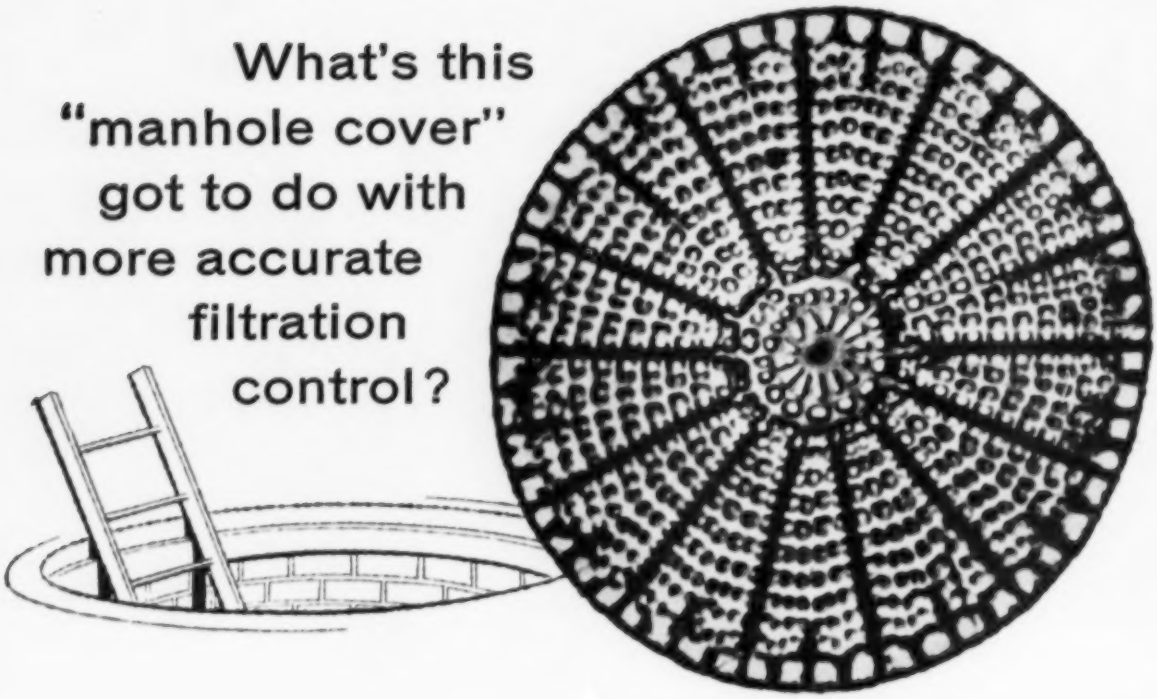


TA-7009-PP3

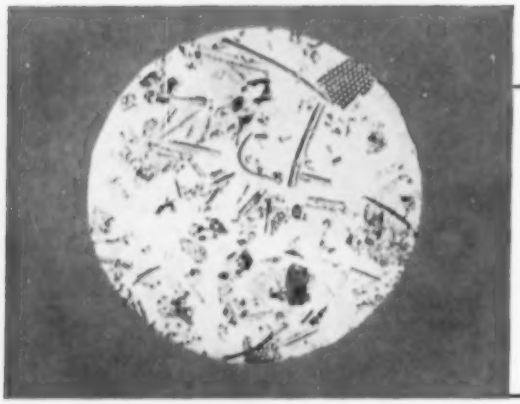
Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steel.

THIS "MANHOLE COVER" is really a magnification of *Arachnoidiscus ornatus*, one of the hundreds of different intricate particles that make Celite such an effective filter aid.

What's this "manhole cover" got to do with more accurate filtration control?



It's a particle of CELITE with the



The photomicrograph at left shows the wide variety of particle shapes and sizes in a typical Celite sample. By carefully controlling the proportions of particle sizes, the most complete range of grades is obtained.

Johns-Manville CELITE



Celite's wide range of grades permits precise control of several different filtration operations in the brewing of beer and ale. These include various ruh beer filtrations, wort filtration, final beer polishing and purification of brewing and bottle wash waters.



In industry's modern research laboratories, Celite filtration has proved itself an indispensable tool. Special grades of Celite have been developed that are particularly effective in analytical methods requiring filtration or chromotographic study.



In the manufacture of lubricating oils, Celite filter aids completely remove bleaching clay from the oil itself and also clarify the many additives used by the industry.

-the diatomite filter aid widest range of grades

Need maximum clarification? Use Celite* Filter-Cel. Or does your filtration require the fastest flow rates? Then use Celite 545. In addition, there are 7 more intermediate grades plus many special grades produced for specific applications. Thus, with Celite, you can establish the exact balance of clarity and flow rate that your process requires. No other diatomite gives you such a wide choice of grades.

Celite also gives you other important advantages over competitive filter aids. Its lower wet density provides greater surface coverage per pound. This means substantial savings because six bags of Celite actually do the work of seven bags of other diatomites.

And Celite is uniform. Every pound of Celite comes from the world's largest and purest commercially available diatomite deposit. Every pound is processed and graded at the same plant under the same conditions. Yet, with the large inventory maintained at the plant and Johns-Manville's nationwide network of warehouses, you're assured of fast, sure delivery.

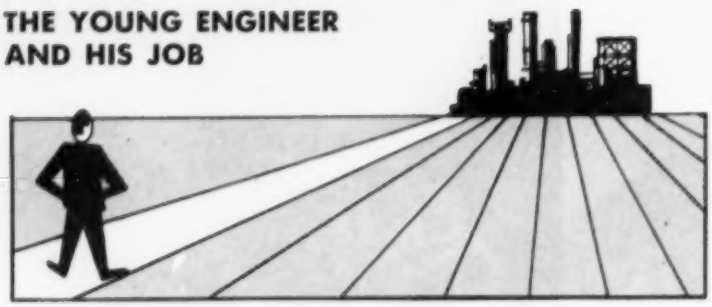
So, if filtration belongs in your processing operations, it will pay you to call in your local J-M Celite engineer. Backed by Johns-Manville's research facilities and years of practical diatomite experience, he can help you with your filtration problems. Call him today or write Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ontario.

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

Diatomite Filter Aids

JOHNS-MANVILLE JM PRODUCTS

THE YOUNG ENGINEER AND HIS JOB



V. L. Shipp [*]

Brooklyn Polytechnic Institute
Brooklyn, New York

The importance of technical knowledge allied with good personal qualities is pointed up for the benefit of the engineer for some years in industry but who is seeking promotion or change of assignment, and of the young engineer about to sign up with a company and go to work.

Among the many jobs made available to the young engineer by industry, which should he select? What do industrial managements expect from young engineers? What type of training should the young engineer expect to receive in business firms? What is the normal progress of a young engineer during his first five years or so?

Training and Knowing

On the subject of training, formal courses with lectures, shop practice, and homework are planned only in those industries where highly specialized products or procedures are involved. Familiarity with subjects such as electronic computers or advanced applied nucleonics cannot be expected from many engineers, hence industry is compelled to supply such knowledge so that the engineer can understand what is going on around him and become a useful member of the staff.

The training usually given the engineer is a training "on-the-job." This usually means working with a senior staff member who tells him *what* to do and *how*. The engineer may spend a short period in the analytical laboratory to learn the methods of testing and to become acquainted with the major products; he may be assigned for a short time at the plant to study at first hand the basic steps of manufacture; or, in the case of engineers entering sales departments, time may be included on the agenda for him to look into the routines of order processing, deliveries, retail practices, etc. However, none of these facets of training on the job can be construed as a passive absorption of knowledge similar to class work in college. It is rather a kind of "do-it-yourself" under the supervision and guidance of a more experienced man. By means of this procedure the engineer begins to ask himself such questions as: am I interested in the purpose of the work I am doing? Do I understand why the problem I am working on originated? Do I grasp the meaning of that part of the project with which I am entrusted? Have I asked when I did not know?

The engineer in most instances is never in doubt about where he stands in the estimation of his company's officials. His supervisor, after observing him closely over a period of time, informs him when he has made a good showing, tells him how he can improve his work, and suggests, in some instances, night courses to supplement his knowledge (with the financial help of the company). He, in turn, is invited to express his opinion of the supervisor's judgment, to state how happy (or otherwise) he is with the job, and to indicate where in the company he might turn to better account (for the benefit of the company and of himself) both his training and his talents.

Weighing Personal Qualities

Technical knowledge, important as it is, is not the only criterion on which the engineer is rated; personal qualities weigh heavily in the scale. Item by item the ratings may cover the following:

- *Knowledge of the job:* knowledge of basic theories, understanding of applied method, familiarity with equipment, knowledge of related jobs.
- *Performance on the job:* planning of work, skill in use of materials and equipment, productivity, initiative and originality, judgment, perseverance, work quality, progressiveness.
- *Personal qualities:* ability to get along with people, tact, emotional stability, cooperativeness, dependability, loyalty, health, appearance, leadership, skill in making contacts.

Balancing Knowledge and Personal Traits

From the qualities listed above, it is evident that management is seeking a proper balance of technical aptitudes with personal qualities, particularly those personal traits which enable the employee to get along with other people. There is a good, deep-seated reason for such an attitude on the part of management. In an industrial organization everybody works as a member of a team, everybody needs the cooperation of other workers around him. This harmonious working together on a company's problems is the key to success in business. Members of the team are not only those who are in the same room; they may be in another department, in another building, or in another town and still be invisible but important members of the team. If an employee works in the engineering department on a design of some process unit, it is necessary that he coordinate his work with the technical men at the plant who know the availability of space, utilities, and the method of fitting the new unit into the existing operations. The purchasing department must also be consulted on availability of materials and supplies and their cost. In this same engineering department one would want to make use of the men specializing on pumps, piping, and foundations.

Some jobs require more scholastic background and mental concentration than ability for working under orders and giving orders. Other jobs are the other way around, but no one in industry can make a career based on scholastic aptitudes alone, any more than he can on abilities to get along with people alone.

Rotating Exceptional Engineers

To continue with the progress of the young engineer: if his specific aptitudes strongly indicate that he would be more useful and happier on a job different from the one he has been doing, he is usually given such a chance as soon as management is able to make pertinent relocations in the staff. Otherwise he may continue in the same department where his supervisor will see to it that he is given increasingly bigger, more satisfying assignments commensurate with his growing experience.

Many companies have adopted the policy of rotating a more promising

(*Continued on page* 16)

[*] Based on an address before the Student Chapter of A.I.Ch.E. at Brooklyn Polytechnic Institute. Mr. Shipp is Adjunct Professor in the Chemical Engineering Department.

How to evaluate materials of construction for the chemical plant

Choosing materials of construction for chemical-industry equipment is a complex job. The first step toward the solution of a new problem is the analysis of all the requirements that can be anticipated. If they indicate one or more of the properties shown, chances are that Crucible *stainless* steel is the most practical choice you can make.



RESISTS CORROSION – Stainless is almost impervious to attack by oxidizing acids like nitric acid. It resists strong alkaline solutions, and many other chemical compounds.

PREVENTS CONTAMINATION – With stainless there's no pickup of metallic ions or deterioration in the product. Stainless stays out of the process solution.





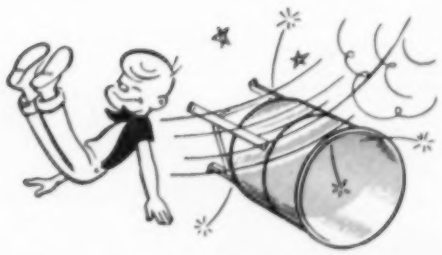
CLEANS EASILY–Even for the most rigorous cleaning problem – that of decontamination to remove radioactive matter–stainless is chosen decisively over other materials.



WITHSTANDS TEMPERATURE EXTREMES – At very high temperatures, stainless stays strong. At very low ones, it does not become brittle as other metals may.



PROVIDES GREAT STRUCTURAL STRENGTH –Stainless is about 50% stronger than mild steel. It permits lightweight, durable construction of chemical processing equipment.



RESISTS WEAR AND ABRASION – Erosive and abrading action makes the surface of stainless harder. It's ideal for mixers, chutes, bins and piping.



ALLOWS COMPLEX FABRICATION–Stainless can be cut, bent, drawn, welded, machined, forged, spun, riveted, cast–fabricated by all the common metal-working processes. Stainless imposes no restrictions on equipment design.

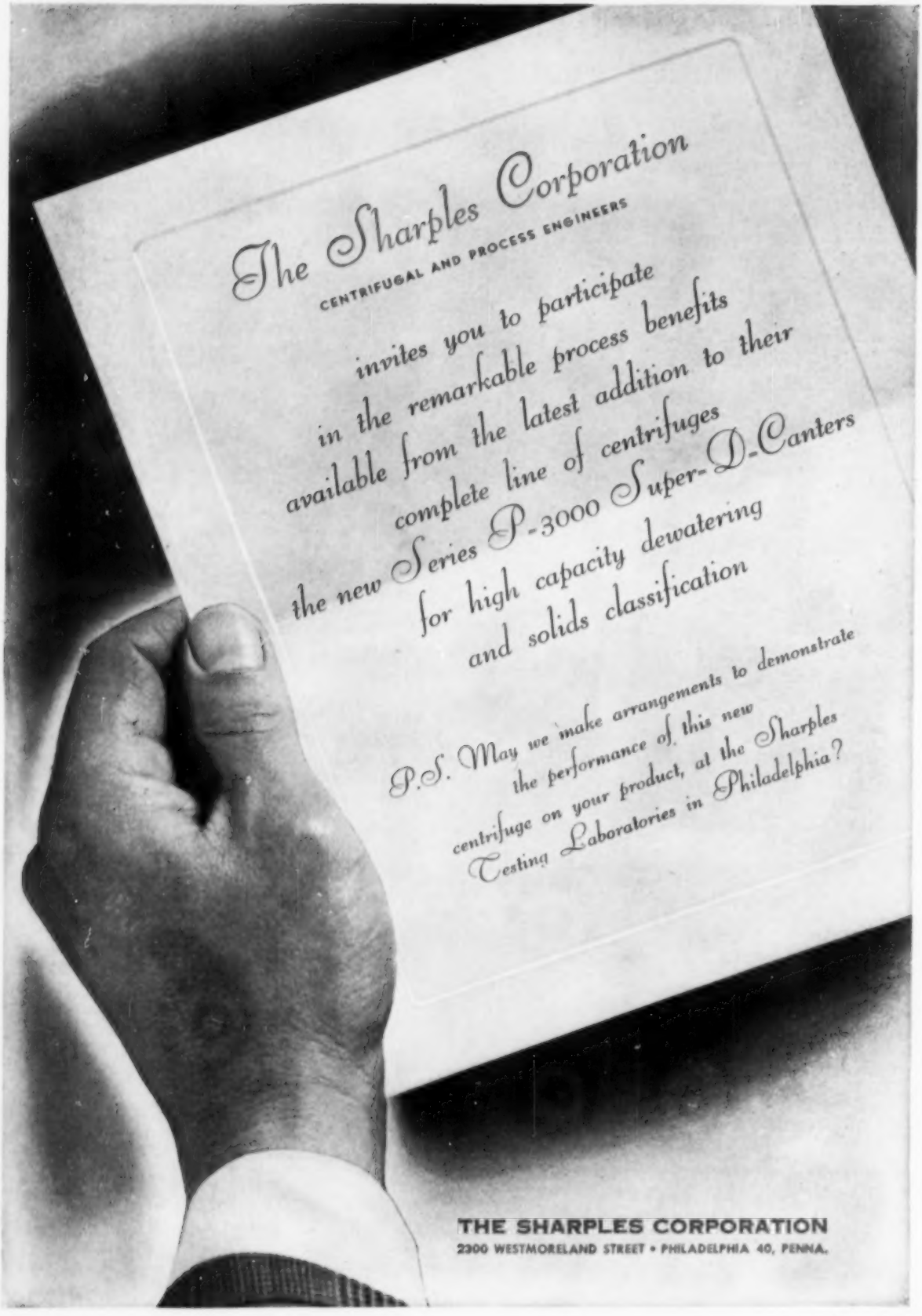
Crucible metallurgists have had considerable experience with stainless in chemical applications. They will be happy to work with you to make the best, most economical use of stainless in your plant. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

Send for a copy of the 44-page booklet "Making the Most of Stainless Steels in the Chemical Process Industries". It's packed with data you can use.

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor – Railway & Power Engineering Corp., Ltd.


The Sharples Corporation
CENTRIFUGAL AND PROCESS ENGINEERS
invites you to participate
in the remarkable process benefits
available from the latest addition to their
complete line of centrifuges
the new Series P-3000 Super-D-Canters
for high capacity dewatering
and solids classification
P.S. May we make arrangements to demonstrate
the performance of this new
centrifuge on your product, at the Sharples
Testing Laboratories in Philadelphia?
THE SHARPLES CORPORATION
2300 WESTMORELAND STREET • PHILADELPHIA 40, PENNA.

40 Forward Years FOR CROLL-REYNOLDS

1917 Croll-Reynolds Co. established; work on EVACTORS, started previously by the two founders, now enters new phase.

1920's Croll-Reynolds contributes greatly to the power field's efficient use of intercondensers between stages for steam economy.

1930's Croll-Reynolds focuses on the need for high vacuum in the growing chemical field—gives special attention to design of 4 and 5 stage EVACTORS, and also to the application of steam jet refrigeration equipment.

1940's Croll-Reynolds directs activity toward war effort, supplies a great number of EVACTORS for shipboard use, special units for the atomic program, and equipment for manufacturing new types of explosives and chemicals. **In the late 1940's,** Croll-Reynolds develops and supplies vacuum equipment for vacuum cooling of fresh vegetables.

1950's Croll-Reynolds develops special condensing tower used to recover entrained materials and to prevent contamination of cooling water—especially adaptable for deodorizers in the fatty acid and allied industries.

PRESENT Croll-Reynolds continues to develop and perfect new kinds of jet and condensing equipment with the knowledge and skill that has enabled the Company to establish an enviable record. In its Forty Forward Years, Croll-Reynolds has—

- Supplied equipment for vacuum cooling of fresh vegetables with a combined **daily** capacity of 2000 cars **each** holding 25,000 to 30,000 lbs.
- Designed and manufactured **all** the commercial vacuum cooling equipment **used** to date in the electrolytic zinc industry of the U. S. and Canada.
- Supplied **more** vacuum cooling systems for the Viscose-Rayon industry than **all other manufacturers combined.**
- Pioneered many new applications of vacuum and vacuum refrigeration.

Croll-Reynolds Company, Inc. is confident that in the future, as in the past, they will continue to develop new types of industrial jet equipment and improve existing designs.

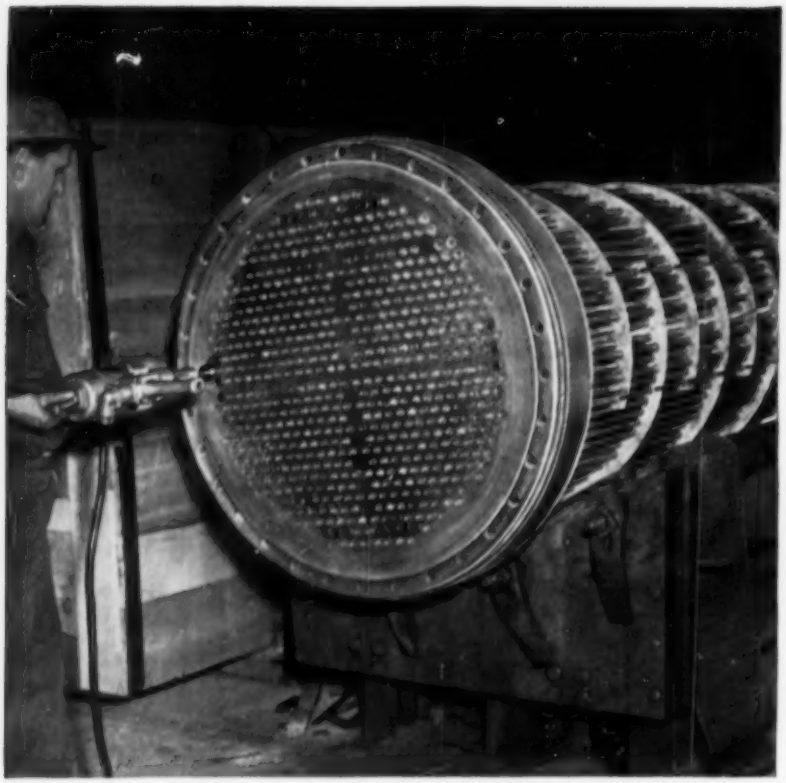
CROLL C R REYNOLDS

Croll-Reynolds CO., INC.

Main Office: 751 Central Avenue, Westfield, N. J.

New York Office: 17 John Street, N. Y. 38, N. Y.

CHILL-VACTORS • STEAM-JET EVACTORS • AQUA-VACTORS • FUME SCRUBBERS • SPECIAL JET APPARATUS



Tricky assembly job handled with ease...at Downingtown

Specs said: Roll type 329 stainless tubes into type 316 and 304 tube sheets. A tricky problem, since the 329 tubes are 15-20 points harder on the Rockwell B scale than the 304 and 316 tube sheets.

What's more, an alert suggestion saved our customer the cost of a test shell, by utilizing the annulus created by the specified double tube sheet construction.

Design Pressure: Shell —125 psi at 300° F.
Tubes— 75 psi at 300° F.
Hydrostatic Test Pressure: 150 psi
Construction: Per ASME Code, Para. U-69...Customer Inspected
Tubes: 608 Stainless Steel Tubes, Type 329 (Carpenter #7MO)
¾" O.D. x 16 ga. x 15' 9" L.
Outer Tube Limit: 30⅝"...4 Pass
Floating Tube Sheets: Two—1½" and 2" thick...32⅜" O.D.
Fixed Tube Sheets: Two—1¼" and 1¾" thick...38⅜" O.D.
Shell Side Tube Sheets: Stainless Steel, Type 304.
Tube Side Tube Sheets: Stainless Steel, Type 316.

Write for helpful heat exchanger design data—Bulletin HE.

Downingtown Iron Works, Inc.
106 Wallace Ave., Downingtown, Pennsylvania
division of PRESSED STEEL TANK COMPANY Milwaukee
Branch offices in principal cities

DOWNINGTOWN IRON WORKS Hackney

HEAT EXCHANGERS—STEEL AND ALLOY PLATE FABRICATION
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

Noted and quoted

(Continued from page 12)

engineer after a minimum of three years of service. This enables him to widen his experience and acquire a broader understanding of problems and activities. It is a test also of his ability to adapt himself to a new environment and new associates. By that time, it is usually sufficiently clear whether the man is more of the studious, research type who prefers to be left to himself as much as possible, or whether within him there is the germ of a leader capable of directing the work of others. The best men of the first type are encouraged to take night courses, and some are selected for fellowships paid by the companies. The potential supervisors have the opportunity to take management courses. Such courses are given either within the companies, or in colleges as a special service to industry. This phase properly may be called the end of the "junior" status and the beginning of life as fullfledged technical man.

Classifying Jobs

All technical jobs may be placed in one of these three groups:

- ***Jobs requiring predominance of scholastic interest:*** researchers, designers, statisticians studying production and quality control, project men on development of analytical methods.
- ***Intermediate jobs:*** operators of full-scale and pilot plant equipment, project men in laboratories and engineering departments, product application workers, market analysts.
- ***Jobs requiring predominance of ability to work with people:*** all supervisory and executive positions, from foreman to manager; technical sales jobs.

It is evident that the "introvert" will be happier in jobs of the first group, "extroverts" in jobs of the second. Unless the young engineer has already traced his personality pattern in college through a vocational guidance department, it would be wise for him to "find himself" with the aid of a reputable psychological laboratory. Reliance on one's own judgment is tempting, but frequently misleading since we all have a more or less distorted picture of ourselves. Certain readjustments of personal traits are possible as we continue working with others and learn from mistakes. The basic personality of a young engineer is formed at this phase of his life, however, and selection of a job dovetailed with his individual makeup will save him from disappointment and loss of time.

Selection of a job on the basis of geographical location and size of com-

(Continued on page 46)

Layne knows more about water bearing formations!



On whose say-so? Not on ours—but on the experience of scores of American and foreign firms and municipalities whose very existence and success depend on an adequate supply of water.

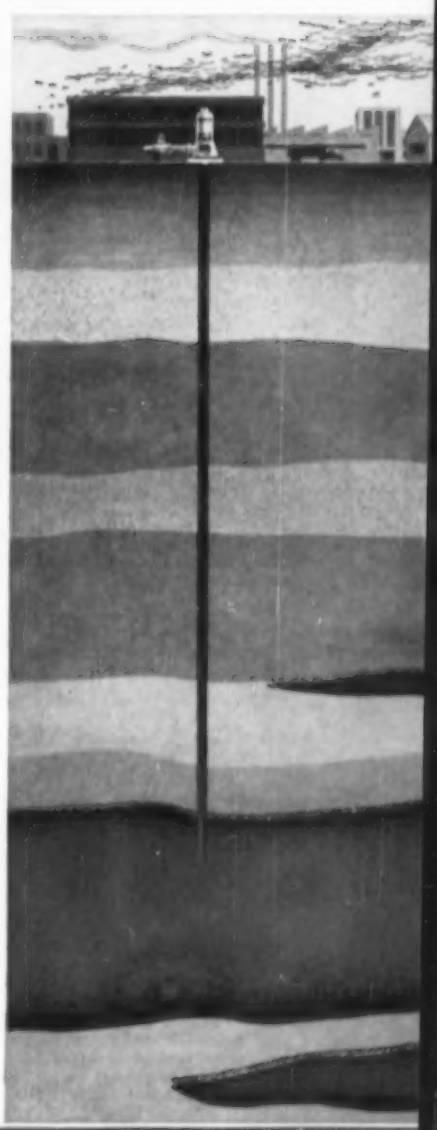
Knowing where the water is — and then tapping the subterranean source is but a part of the vast knowledge the Layne organizations have accumulated in three quarters of a century.

Once the source is determined and the water supply developed, a dependable means for delivering the water must be provided, and that's where the famous Layne pump comes in. For each Layne pump is specifically engineered for the particular job. There is no "stock" Layne pump. Your pump is created for your job —making use of the knowledge of strata, water requirements and usage.

ENGINEERED, DEPENDABLE PERFORMANCE IS WHAT YOU GET WHEN LAYNE DOES THE JOB— COMPLETE FROM WATER LOCATION TO YEAR AFTER YEAR OF TROUBLE-FREE PUMPING.

YOUR NEXT WELL AND PUMP INSTALLATION MAY BE MONTHS OFF. GET TO KNOW THE LAYNE FOLKS IN YOUR AREA. SAVE TIME AND MONEY THROUGH THEIR INTIMATE KNOWLEDGE OF WATER.

Send now for our general services bulletin No. 100.



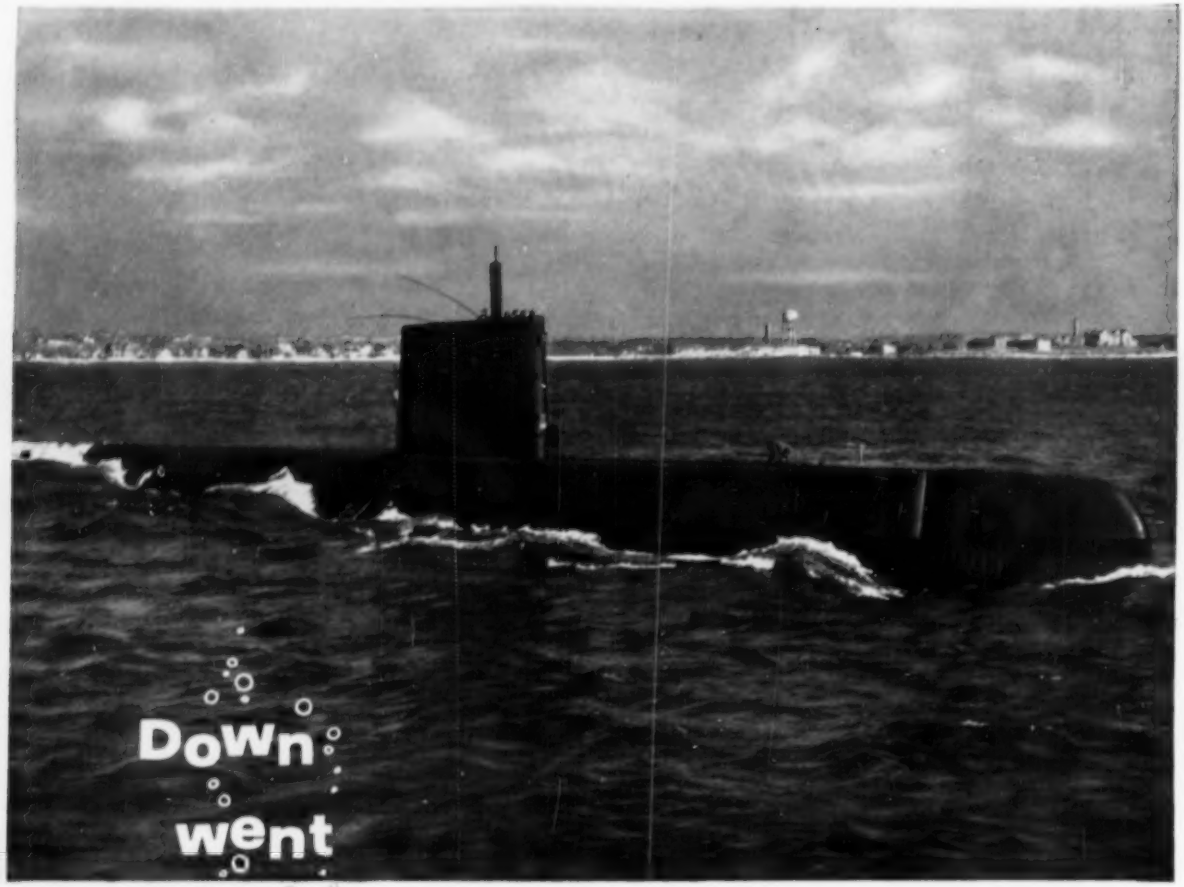
1882 — 1957
Layne
75 YEARS OF PROGRESS

WATER WELLS • VERTICAL TURBINE PUMPS • WATER TREATMENT

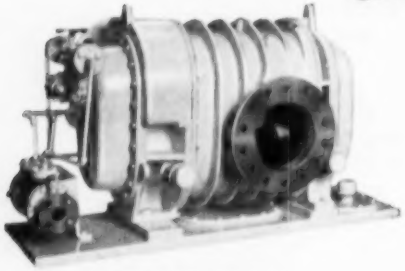
LAYNE & BOWLER, INC. MEMPHIS

General Offices and Factory • Memphis 8, Tennessee

LAYNE ASSOCIATE COMPANIES THROUGHOUT THE WORLD



McGinty to the bottom of the sea!



Spiraxial operating data U.S.S. Triton.
7" x 15" Spiraxial compressor rated at 15 psig delivers 1700 cfm at 3550 RPM requiring 83 HP. direct-connected to an electric motor. These Spiraxial compressors are recommended for applications requiring 15 to 30 psig.

Officers and men on board the U. S. Navy's new nuclear powered submarines live under conditions rarely experienced before in undersea craft. Because these ships can cruise for long periods to every corner of the world without refueling, the safety and comfort of the crew are of greater importance than ever.

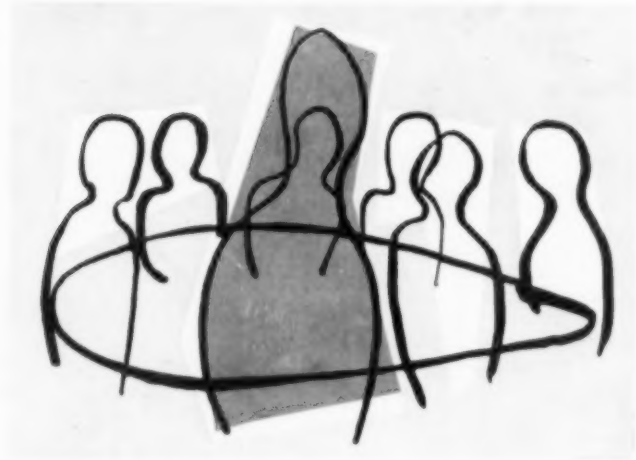
To provide without fail both adequate ventilation exhaust and air pressure for ballast blowing, the U.S.S. Triton and other submarines now under construction are equipped with Spiraxial® compressors manufactured by Roots-Connersville.

These dual-purpose units were selected after intensive testing because they offer the advantages of high efficiency at varying operating pressures plus extreme compactness. They operate for ballast blowing and for ship's ventilation exhaust.

This is but one of the many new applications for this versatile air and gas compressor. For information on how industry is putting Spiraxial to work, write for Bulletin SC-354.

Engineers—unusual career opportunities await you at Roots-Connersville. Address your resume to Professional Employment Manager.

ROOTS-CONNERSVILLE BLOWER
A DIVISION OF DRESSER INDUSTRIES, INC.
757 Indiana Avenue, Connersville, Indiana. In Canada—629 Adelaide St., W., Toronto, Ont.



THE NATURE OF TEAMWORK IN DECISION MAKING

Richard W. Wallen | Creelman Associates, Cleveland, Ohio

Executives today probably have more adequate facts at their disposal than ever before. And yet these facts, to be of any use, must ultimately be interpreted and acted upon by people. No matter what kind of data are obtained, they can be looked upon in various ways, depending upon the attitudes of the people who interpret them.

The increased volume of information flowing today, with the promise of more in the future as electronic data processing serves its purpose, does not simplify management's task. Instead, it demands increased care in both the collecting and interpreting of factual information. This has led to increased use of teams of people—teams made up of both specialists and managers—to ensure that the new tools may be properly used. This article will examine the human factors involved as teams of such individuals undertake problem-solving and decision-making and bring the findings of modern psychology to bear on the problem of team efficiency.

There are many kinds of management decisions, but they can be arbitrarily classified into a few broad types.

The first is *goal setting*, or deciding what standards of performance the company should reach. These include goals for profits, cost reduction, production, or handling personnel.

A second kind of decision involves *capital appropriation*. Such problems as expansion, diversification, and size of inventories of raw materials and finished goods are included here.

A third type of decision concerns *budget allocations* within the company: How much should be spent for research or for advertising? What proportion of research funds should go to basic research and what proportion to product development?

Fourth, management must make decisions about *personnel*, particularly executive personnel. How are they to be obtained, trained, allocated, and evaluated? How can we pick good executives?

Top management also must make decisions about *organizational structure*: shall we combine two departments or divide an existing one? How much centralized control shall we have? How adequate are our communications?

Feeling the Need

All of these *types* of decisions require similar steps to find the *proper* decision. They all start with some kind of discomfort, sometimes called a *felt need*. It is not enough for a problem to exist. The crucial point is whether it is felt and thus recognized as a problem by the management group. Not all needs are actually recognized. For example, men at high altitudes may need oxygen greatly without knowing it. They believe they are doing a wonderful job, but an objective evaluation will show that their performance is very poor. The same is true of other kinds of needs. A president or vice-president may be surrounded by problems that ought to be faced, but he may not experience them as *felt needs*. Consequently, he does not face them until they have become so serious that they can no longer be neglected. A team can often help him recognize such needs.

Sometimes a vague kind of *felt need* exists when an executive feels that something is wrong but cannot identify the source of the trouble. Thus, he may vaguely worry about available capital or production costs, even though he has no clear picture of the actual situation. The worry does not, by itself, tell him what the problem really is. Therefore, the next step is to obtain a more precise definition of the problem.

The formulation of a management problem requires a diagnosis of the causes for the worry or *felt need*. Failure to make a careful diagnostic survey may lead to action that only increases trouble. Physical headaches may result from a number of ailments; it would be stupid to perform a brain tumor operation for all of them, and the same is true for organizational headaches. The removal or the scolding of a division head can't accomplish much if the real difficulty lies in inconsistent company policy.

Stating the Problem

The way that a problem is stated makes a difference in the adequacy of the solution that is reached. Vague terms allow many interpretations, and, where a team is concerned, people may find themselves unintentionally working at cross purposes. Considerable thinking and soul-searching are required to phrase a problem properly. Often, management people do not include themselves in the statement of a problem. To illustrate: how seldom does one hear an executive seriously ask, "What attitudes of mine must I change in order to use market survey information properly?" The more common way of stating the problem is, "How can I get those market survey people to do a better job?"

Reaching the Decision

After alternative courses of decision-action have been explored, a decision must be reached. The way the decision is reached is of great significance, for

(Continued on page 20)



the nature of TEAMWORK

(*Continued from page 19*)

some *techniques* of decision-making leave buried resentments and apathy in their wake. Effective action to implement the decision is then nearly impossible. Decisions that do not result in action mean that the team has wasted most of its time. Only on a basis of understanding, morale, and spirit appropriate to the specific conditions, can rational decisions be made.

It should be clear by now that we cannot improve decision-making by more data and more data-refinement operations alone. The nature of the manager-specialist team that works on the problem must be taken into account. And, along with that, we must consider the impact of the decision on the other people who make up the company. Top management problems, after all, affect the total organization; indeed, they arise because of the need to reconcile conflicting pressures from various parts of the company. And the solutions are greeted with mixed emotions in some quarters.

Twenty years ago, there were few practical suggestions for improving decision-making. Today, help is available for those who sincerely want to improve the performance of teams and committees. This does not mean that improvement is a simple or easy matter. The training of team members requires skill, time, and special conditions, but it can be done. More will be said about this later.

At this point, it will be useful to consider the marks of a useful decision.

There are at least three criteria:

***First,* a useful decision must satisfy the need that produced the problem. It must resolve a situation that required resolution.**

***Second,* the decision should not create new difficulties if these can possibly be avoided.**

***Third,* the decision must be one that can be carried into action.**

Where are teams most likely to fail in trying to meet these criteria? What could possibly lead to decisions that would fail to resolve a situation? We have already suggested one factor: failure to make an adequate diagnosis of the situation so as to ask the right questions. Another cause is to be found in the use of vague terms. Scientists and logicians concerned with semantics can tell us a good deal about this matter, but I would like to call attention here to a common question that sounds like a problem but isn't. That question is, "How can we make more profit?" I submit that this is not a properly stated problem. It defines an area of interest and concern, but it does not pose a meaningful problem. That becomes evident if you note the reaction to the following solution: "simply cheat the consumer in every way that you can, fire your whole research department, and cut the salary of every top executive in half." This solution is not acceptable because it violates some unstated limitations as to the kind of solution desired. But the statement of the problem must include the limitations that are to be imposed on the solution. If the reputation of the company is to be maintained and its continued growth assured, then these conditions must be made explicit. Certainly, one of the tasks of scientists on a decision-making team is to push for the phrasing of problems in a complete and clear way.

A third reason for decisions that fail to solve problems is that the decision-makers neglect data. They may not consider what the data actually mean. Such neglect may have many sources. Some management people are not receptive to certain data because they do not understand how the data were gathered and processed. Confronted with a page of equations that resembles a Greek manuscript, they may listen politely and then deal with the problem in terms they understand. Their unwillingness to consider data is even stronger when the conclusions conflict with some cherished belief.

Another source of the failure to use data properly can be found in the private value systems of the decision-makers. We all have personal views about the important and the unimportant things in business. When a set of figures is presented, we tend to place our private interpretation on them, usually without revealing the basis for our interpretation to other people in the group. Thus, a cost reduction of ten per cent is a basis for optimism in one man and for pessimism in another. An executive who is familiar with mathematics may react favorably to the optimum solution of a linear programming problem; another, who has always disliked mathematics, may consider the solution irrelevant to the really important issues. Finance people tend to look at one side of the problem, personnel men look at another side, and the sales department can be depended upon to view the whole matter differently.

One of the strengths of the team approach is that it offsets the private interpretations of individuals or creatively combines them. In order for this to happen, however, team members must be able to tolerate and even to value differences of interpretation. Then each one will feel free to speak openly and contribute to the final decision. In this way, the team decreases the risk of overlooking pertinent aspects of its information.

Sometimes teams fail to solve problems effectively because they do not formulate enough alternative solutions. They lack the creativity needed for the task. Of the many reasons for this lack, one of the most common is the suppressive effect of prestige and power. Here is what can happen: a person with considerable prestige and power suggests a solution or a course of action. Now, he may want it considered only as a suggestion, but his subordinates react differently. Affected by an attitude that is hardly conscious, they begin to think chiefly in terms of his ideas and lose the motivation to voice or even to think of other possibilities.

Some striking experimental confirmation of this point appeared not long ago in a study by Torrance (*1*). He was interested in the consequences of power differences in three-man decision-making groups. He studied a number of bomber crews, each composed of pilot, navigator, and gunner. The pilot had the most power and prestige, and the gunner had the least. Torrance presented these crews with several different kinds of problems, but we shall mention only one as an illustration. "Suppose that a man buys a horse for $60 and sells it for $70. Later he buys the same horse for $80 and sells it for $90. Does he make

(*Continued on page 22*)

REFERENCES ON GROUP METHODS

Cartwright, Dorwin, "Achieving Change in People: Some Applications of Group Dynamics Theory." *Human Relations,* **4** (4), 381-92 (1951).

Educator's Washington Dispatch (New London, Connecticut), "Two Lessons in Group Dynamics: So You Appointed a Committee; When You Run a Conference." Pamphlet, 11 p. (1948).

Goodson, Max R., and Gale Jensen, "Workshop on the Larger Organization." *Adult Leadership,* **3** (3), 13-29 (September, 1954).

National Training Laboratory in Group Development, "Explorations in Human Relations Training—an assessment of experience, 1947-1953." 87 p.

Wallen, Richard W., "Opsearch and Teamwork." *Chem. Eng. Progr.,* **53** (1), 8-J—9-J (January, 1957).

LOW INSTALLATION COSTS BEHIND

LOW OPERATING COSTS AHEAD!

on self-supported

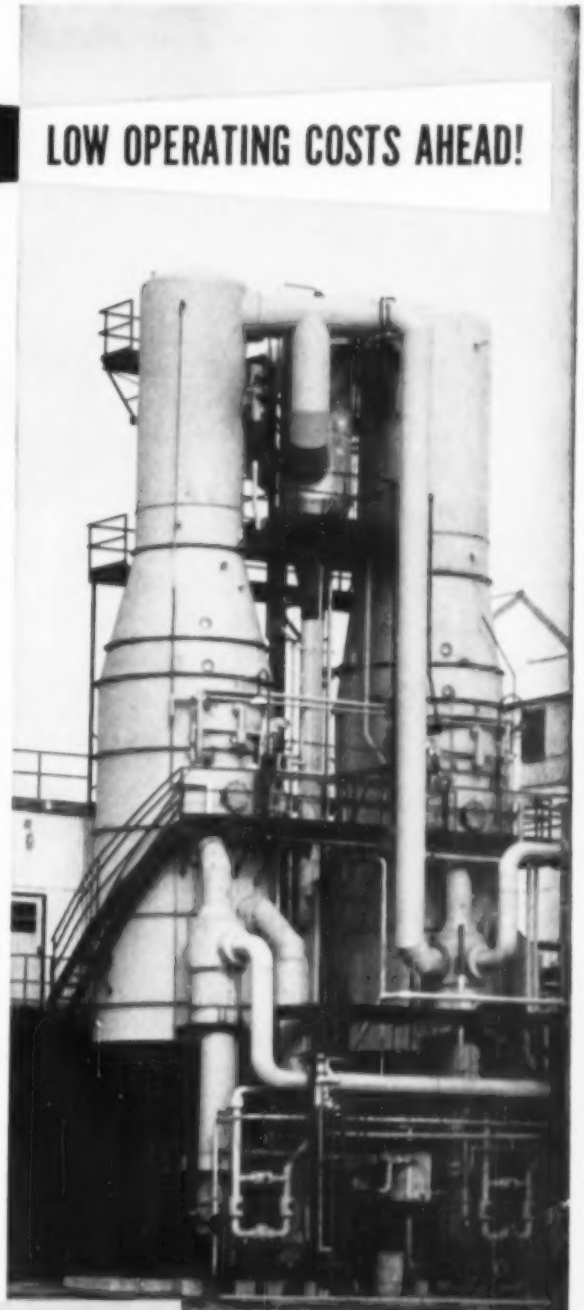
CONKEY®
EVAPORATOR-CRYSTALLIZER

producing Ammonium Sulfate for
National Aniline Division

This double effect, evaporator crystallizer is used to produce crystalline ammonium sulfate and recover caprolactam monomer, raw material for Caprolan, (Allied Chemical's polyamide fiber) at National Aniline Division's Hopewell, Virginia plant. It is a completely self-supported structure —bubble tray column, vapor disengaging chamber, crystallizing chamber and support skirt are all assembled along the same center line.

Compact, unitized "out-of-door" construction such as this is another example of how Conkey "know-how" is helping progressive processors realize the benefits of low installation and erection costs and make maximum use of space. Optimum return for capacity, high crystal uniformity and characteristically low steam consumption provide maximum return on capital invested in Conkey systems.

Conkey crystallizers, for batch or continuous operation, are fabricated by CB&I in four strategically located, completely equipped plants. Laboratory facilities are available for pilot testing of samples. Write our nearest office for details.



Conkey double effect self-supported crystallizer producing ammonium sulfate. One of several "out-of-door" systems used at National Aniline Division's Hopewell, Virginia plant.

CONKEY CB&I EQUIPMENT

Chicago Bridge & Iron Company

Atlanta • Birmingham • Boston • Chicago • Cleveland • Detroit • Houston
New Orleans • New York • Philadelphia • Pittsburgh • Salt Lake City
San Francisco • Seattle • South Pasadena • Tulsa
Plants in BIRMINGHAM, CHICAGO, SALT LAKE CITY and GREENVILLE, PA.
REPRESENTATIVES AND LICENSEES:
Australia, Cuba, England, France, Germany, Italy, Japan, Netherlands, Scotland

CC-33

OPPORTUNITIES FOR TRAINING IN GROUP DYNAMICS

Annual Summer Laboratory in Human Relations Training: National Training Laboratory in Group Development. Gould Academy, Bethel, Maine.

For details, write: Dr. Leland P. Bradford, Director
National Training Laboratories
1201 16th Street, N.W.
Washington 6, D. C.

Community Human Relations Annual Workshop.

For details, write: Morris L. Haimowitz, Director
Human Relations Center
University of Chicago
19 S. La Salle Street
Chicago 3, Illinois

Annual Summer Laboratory Program—Columbia Teachers College.

For details, write: Group Development
Columbia University Teachers College
New York 27, New York

Annual Boston University Workshop in the Improvement of Human Relations.

For details, write: Kenneth D. Benne, Director
Boston University
Human Relations Center
308 Bay State Road
Boston 15, Massachusetts

Annual Western Training Laboratory in Group Development.

For details, write: Department of Conferences and Special Activities
University Extension, University of California
Los Angeles 24, California



the nature of TEAMWORK

(*Continued from page 20*)

any money in the horse trading business, and if so, how much?" This problem has a perfectly clear-cut answer. Torrance was interested in finding out whether the status of the crew member who had the correct answer influenced the acceptance of this answer by the other members. He first asked each member of the crew to write down his own answer. After this, the crews conferred until they agreed. Analysis of the results showed that when pilots, as individuals, obtained the correct answer, only six per cent of them failed to convince the rest of the crew. Among navigators who knew the correct answer, 20 per cent failed to convince the entire crew. But 37 per cent of the gunners who had the correct answer could not influence the crew to accept it. Clearly, truth is more effective if it is voiced by a person with power and prestige! The sober lesson here is that, when a man meets with his subordinates, his ideas will be accepted as much because of his position as because of the value of his ideas.

Teams must guard against this kind of outcome. It requires careful training of both the person with the power and his subordinates, but it can be done. Teams must also learn to guard against quickly submitting to an apparent majority. Often the lone person with a good idea will hold it back when he sees a majority swinging toward a different solution. Some interesting experiments have been conducted on this matter by social psychologists. Their findings reveal that it is extremely difficult for one person to resist going along with the team when he is faced by a united attitude on the part of the rest. This can happen even when he judges the facts correctly. The outcome is quite different, however, if the "lone wolf" is given support by only one other person. When he realizes he is not completely alone, he refuses to back down if he has a factual basis for his views. There is a good lesson here for team leaders:

Since the "lone wolf" may have some answers that the others lack, give him enough support (i.e., responsiveness and consideration) to enable him to make the best case he can. Then the team will not lose a potentially valuable idea.

Failure to invent a number of alternative solutions can also be traced to apathy and resignation. Committees and teams often become disgusted because they have been directed by unskilled and insensitive leaders. The meetings have been uninteresting, frustrating, and leader-dominated. Consequently, the participants are only weakly motivated to search for new ideas. They walk into a meeting with the conviction that nothing will happen, and they are usually right.

Let us examine now the second criterion of useful decisions: they should not create new difficulties. What is responsible for decisions that fail to meet this test? A common reason is that the group members did not represent enough different points of view. If the team is made up of production people only, then they may reach a seemingly satisfactory decision without much trouble. When the decision is acted upon, complaints and dissatisfaction begin to come from sales or from engineering. This situation develops because the team considered only a subsystem of the total industrial organization. They arrived at a decision that was a good one for the subsystem, but it adversely affected the total system. This kind of solution to problems, called "suboptimization" in Operations Research terms, comes about because the team is too homogeneous. There is a prevalent but mistaken notion that when a problem seems centered only in manufacturing or only in research and development, it is not the concern of other divisions.

It is precisely in order to avoid the dangers of hasty suboptimizing that scientists, managers, and engineers ought to serve together on a team. The "long-hairs" and the "slide rule boys" can be accused of ignorance of management problems and thus be excluded from decision-making teams. But this exclusion only perpetuates their ignorance and prevents them from making their distinctive contributions in the most appropriate way.

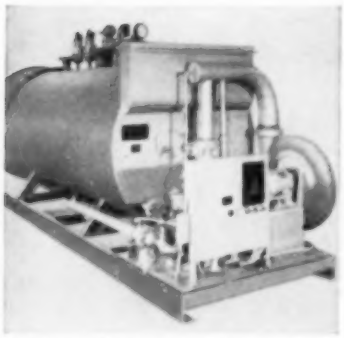
The final criterion of a useful decision is that it leads to action. Why is it that some decisions, apparently sound, get poor results? One reason is that the entire team is not really committed to the decision. Openly announced agreement may often cover inner doubts and reservations about the decision. These attitudes will interfere with an enthusiastic and spirited desire to carry the decision into action. When those responsible for action lack conviction, they may carry out the decision in such a way as to make it ineffective. And they can do this without a conscious intention to oppose the decision.

Even when the decision-making team is really convinced that it has chosen a useful course of action, implementation may be hampered by other people in the organization. Many decisions

(*Continued on page 26*)



Deep cooked . . . and always uniform in color and flavor



A horizontal vaporizer (above) is used by the Wise Potato Chip Co. Low pressure performance (144 p.s.i. at 750°F.) of Dowtherm permits the use of compact, thin-walled equipment.

Wise Potato Chip Company solves uniform process heating problem with Dowtherm, Dow heat transfer medium

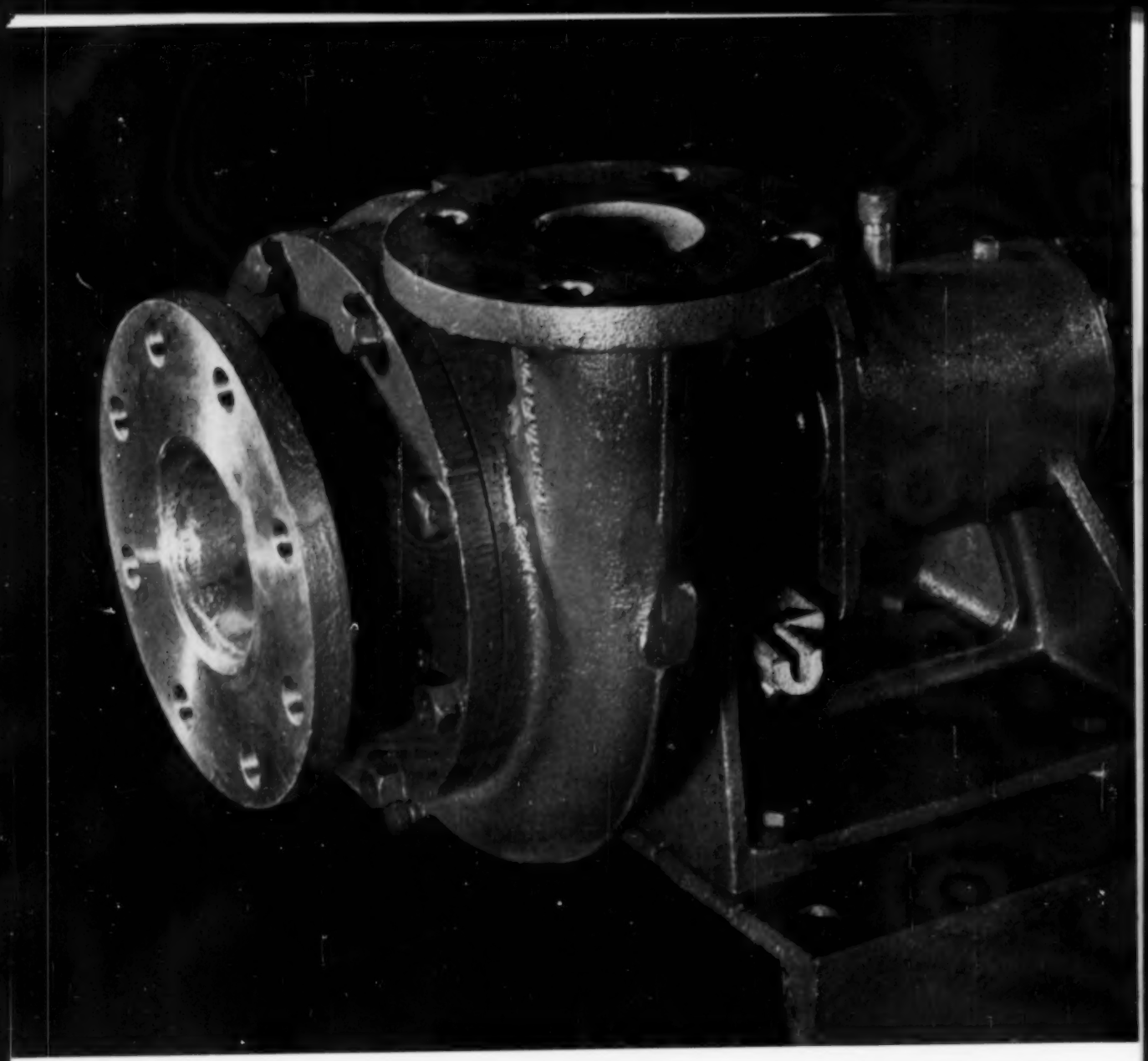
Faced with the unique problem of deep cooking uniform color, taste and crispness into their chips, a few years ago the Wise Potato Chip Company, Berwick, Pennsylvania, sought the answer to maintaining a constant temperature with varying heat loads.

Intense examination of many heating systems led the Wise Potato Chip Company to select an entirely closed heating system using Dowtherm® as a vapor heating medium.

These results were soon apparent; Now heating efficiency is very greatly improved. Fuel costs are reduced. Fire hazards are reduced because with Dowtherm the heating source is placed far from the processing area. Quality is controlled more easily by the use of Dowtherm.

For your own peace of mind, if you have a process heating problem ranging from 350° to 750°F., we advise you to talk with us. We might have the answer that will improve your product—and save your company money. THE DOW CHEMICAL COMPANY, Midland, Michigan, Dept. BD 845J-1.

YOU CAN DEPEND ON DOW



HOW TO BUY A $750

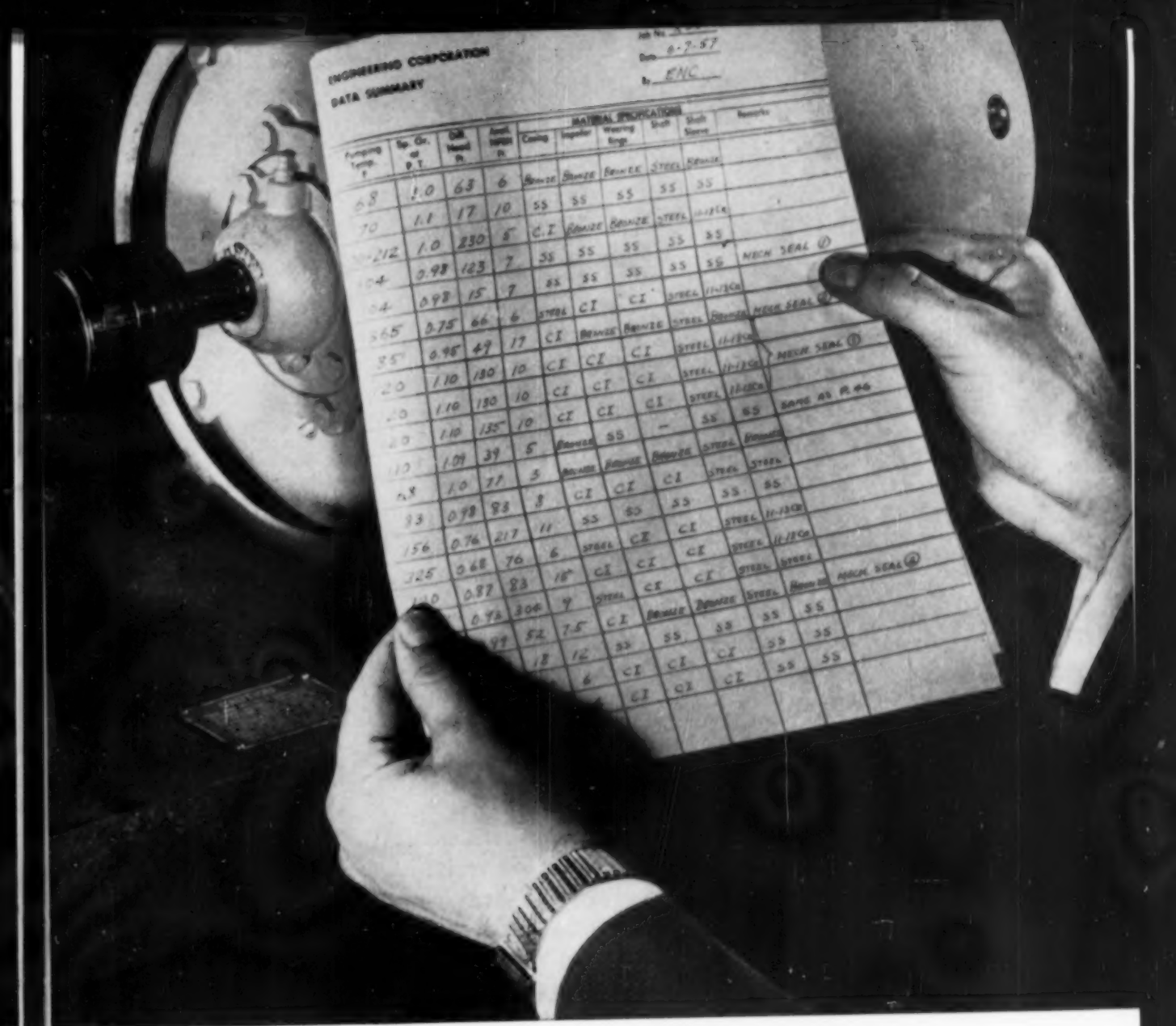
When you need a "special" pump, Worthington's SESC (Standard End Suction Centrifugal) line will often prove the low-cost answer.

For example, the chart above shows specifications for 21 different pumps, with a variety of materials of construction, which would ordinarily involve manufacture of special pumps. However, because all of these materials are available from the SESC line, the pumps can be bought at big savings.

The secret of Worthington's ability to give you many normally special pumps at standard prices is the flexibility of the SESC line. *Parts* have been standardized, but not *pumps*. As a result, you can literally "custom-build" your pump to get exactly the right features to meet your requirements.

70,480 COMBINATIONS TO CHOOSE FROM. You have a choice, for example, of four materials of construction—iron, steel, bronze, Worthite* and combinations of these. You have a choice of five types of liquid ends and five different drives. You can choose packed stuffing box or mechanical seal operation. In all, there are 70,480 combinations—all built from standard, stocked parts and ready for prompt delivery at competitive prices.

*A high nickel, high-chromium, low-carbon alloy steel. Trademark Reg. U. S. Pat. Off.



PUMP FOR $300!

STANDARDIZATION PAYS OFF LATER. After you have installed an SESC pump, you benefit again from Worthington's broad standardization program. Since all pumps in the line are built from interchangeable parts, your spare parts inventory can be cut as much as 50%. Should repairs or conversions become necessary, parts interchangeability can often mean reduced downtime.

The complete SESC line consists of six separate types of pumps, all suitable for either motor, turbine or belt drive. Ratings range up to 2,700 GPM and 550 ft. head. If you'd like to know more, write for Bulletin W-300-B4. Worthington Corporation, Harrison, N. J.



CUTS MAINTENANCE
If you know one SESC pump, you know them all. From the smallest to the largest the entire line is built to the same basic design. Maintenance men quickly become familiar with its construction details.

WORTHINGTON



the nature of TEAMWORK

(*Continued from page 22*)

can be carried out only through the cooperation of lower management and hourly rated employees. If they do not understand the meaning of the new action or if they believe it will decrease their income and status, they will oppose it openly or secretly. The result may very well be disappointing to the decision-makers.

We may summarize this last point by stating a principle of decision-making:

One consideration in every decision must be the willingness of responsible operating personnel to act on it. A rationally perfect decision arrived at by methods that leave operating people resentful, frightened, or confused is not a useful decision.

There can be little question about the value of the team approach when we use people who have been trained for it. Much current dissatisfaction with teams stems from observing the work of groups that are unskilled and badly managed. We do not expect a football team to be effective without coaching, but we think we can seat smart people around a table and get teamwork from them without training. That is a mistaken belief.

What kind of training do group members and leaders need? At least three outcomes must be sought:

1—Familiarity with the stages in group problem-solving and skill in using this knowledge.

2—Sensitivity to the meaning of group phenomena such as holding back opinions, discussing trivial details at length, or forming cliques.

3—Awareness of the impact of one's own actions and words on others in the group.

Such training cannot be obtained by mere reading of books. It must be achieved by actually working with and observing groups. With a sharpened interest in group "phenomena," much awareness can be developed by the individual in the course of his normal conference experiences. Much more leadership technique can be acquired, however, through group training conducted under the guidance of expert trainers. In this kind of training, theory becomes secondary to experience in the specially arranged training groups. Role-playing, discussion, and practice in leading groups also play a part in this training.

Where is such group training available? The National Training Laboratories, affiliated with the National Education Association, has conducted training programs for over a decade and has constantly explored new methods. Its influence has spread throughout the country by means of staff members, trained for its summer programs at Bethel, Maine.

A few universities, notably Michigan, Chicago, Columbia, California, and U.C.L.A. have developed training programs for leaders, and several private consulting firms arrange special training for management groups.

Training for teamwork should not be viewed as a "gimmick" for miraculously resolving thorny management difficulties. Like computers and Operations Research, it is one more important tool to help management toward increasing effectiveness.

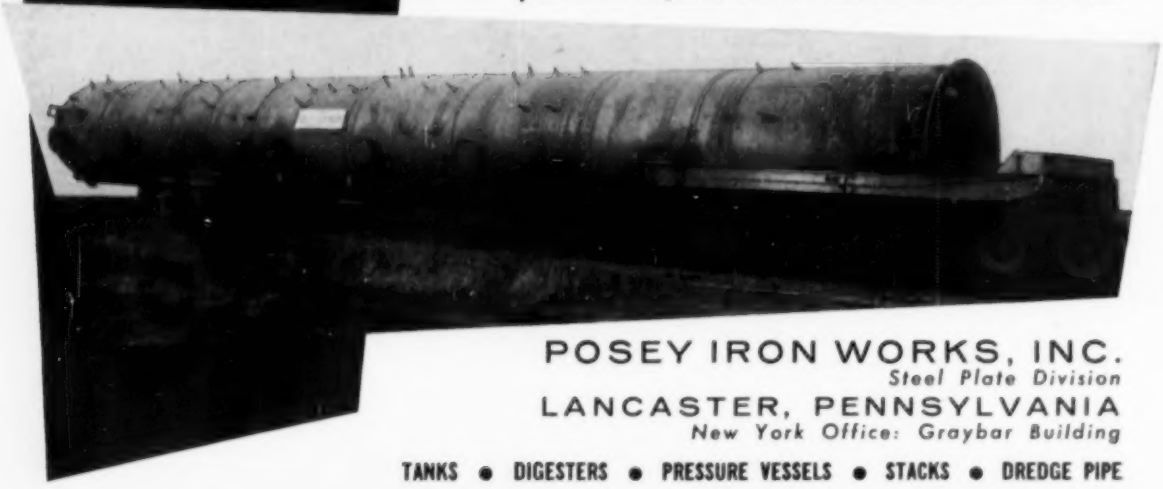
Literature Cited

1. Torrance, E. Paul, in "Small Groups," edited by P. Hare, E. F. Borgatta, and R. F. Bales, Knopf, New York (1955).

Presented at A.I.Ch.E. meeting, White Sulphur Springs, West Virginia.

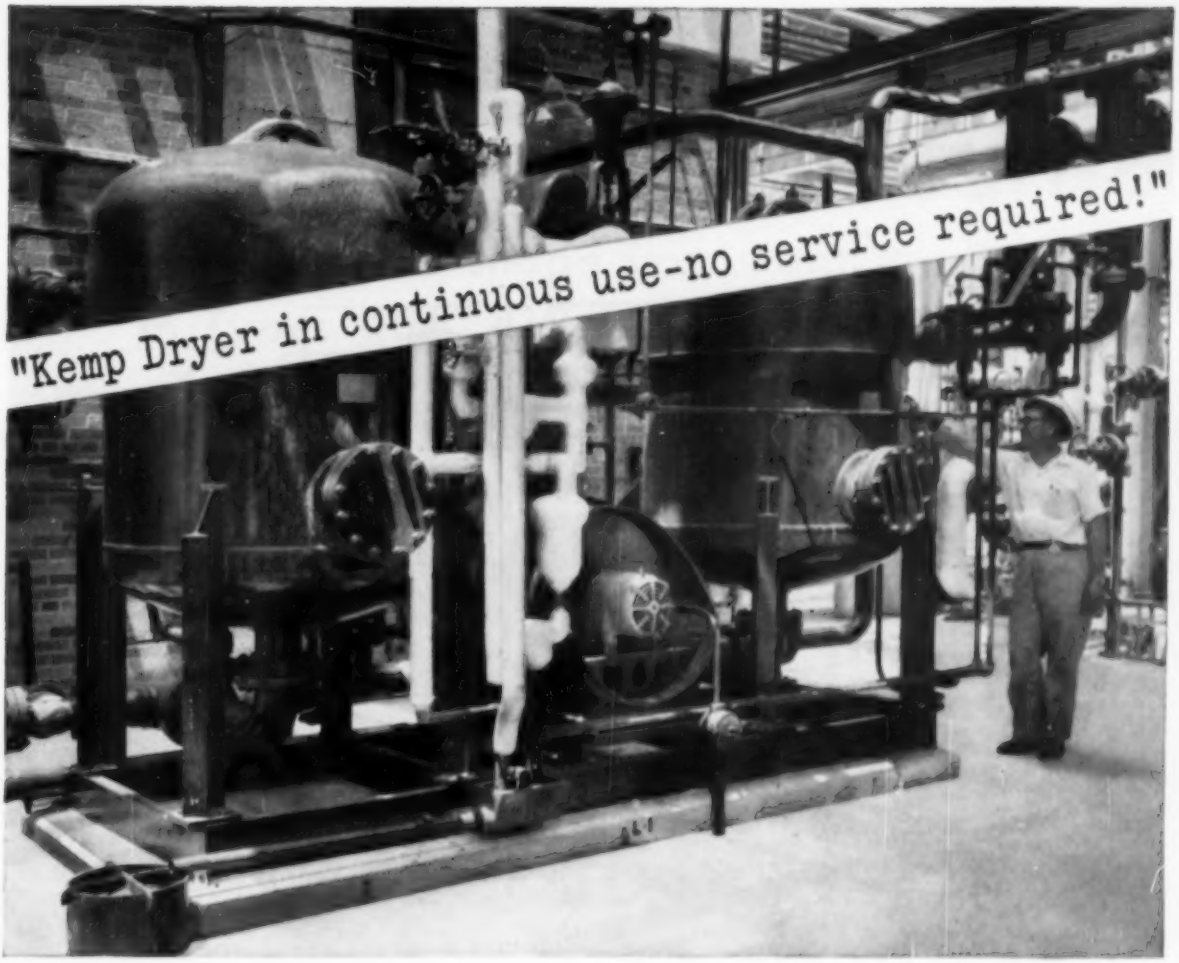
POSEY TOWERS

Feed Splitters like this one . . . 98' long by 10' I.D., and now in service in one of the East Coast's largest plants . . . must be precision-built from beginning to end. Posey Iron has the experience, the facilities and equipment, as well as the skilled men to turn out a flawless job every time. Write for information about Posey installations in your industry. Let Posey quote on your next requirement for fabricated steel structures.



POSEY IRON WORKS, INC.
Steel Plate Division
LANCASTER, PENNSYLVANIA
New York Office: Graybar Building

TANKS • DIGESTERS • PRESSURE VESSELS • STACKS • DREDGE PIPE



Cities Service Petroleum reports:

Kemp Dryer in continuous operation 7 days a week; has required no service or downtime!

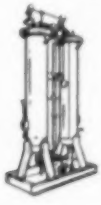
To dry compressed air for instruments in a hydroformer unit at its refinery in Lake Charles, Louisiana, Cities Service Refining Corporation has installed a Kemp Model LC SE2 Air Dryer. Since January, 1955, it has served continuously—seven days a week—drying 1900 cubic feet of air per minute to a dew point of −10° F.

This fully automatic Kemp Dryer, reactivated every 12 hours (or 22,800 cubic feet of air), has so far required no downtime or service at all! And, according to Mr. Glendon L. Smith, Unit Engineer at Cities Service, there is practically no pressure drop from the entering pressure of 285 pounds . . . further indication of Kemp quality and efficiency.

Kemp Dryers for Every Purpose

Kemp offers a variety of dryer models to meet all problems. Designed to dry air, gases or liquids to sub-zero dew points at low cost, they are constructed of quality materials and embody the engineering knowledge gained from Kemp's many years of experience. They are available with manual, semi-automatic or fully automatic tower reactivation. In addition, Kemp will prescribe the proper desiccant for each specific drying job. If you have a problem involving the removal of water from air, gases or liquids, contact Kemp now. For complete facts and technical information, write for Bulletin No. D-100.

KEMP OF BALTIMORE



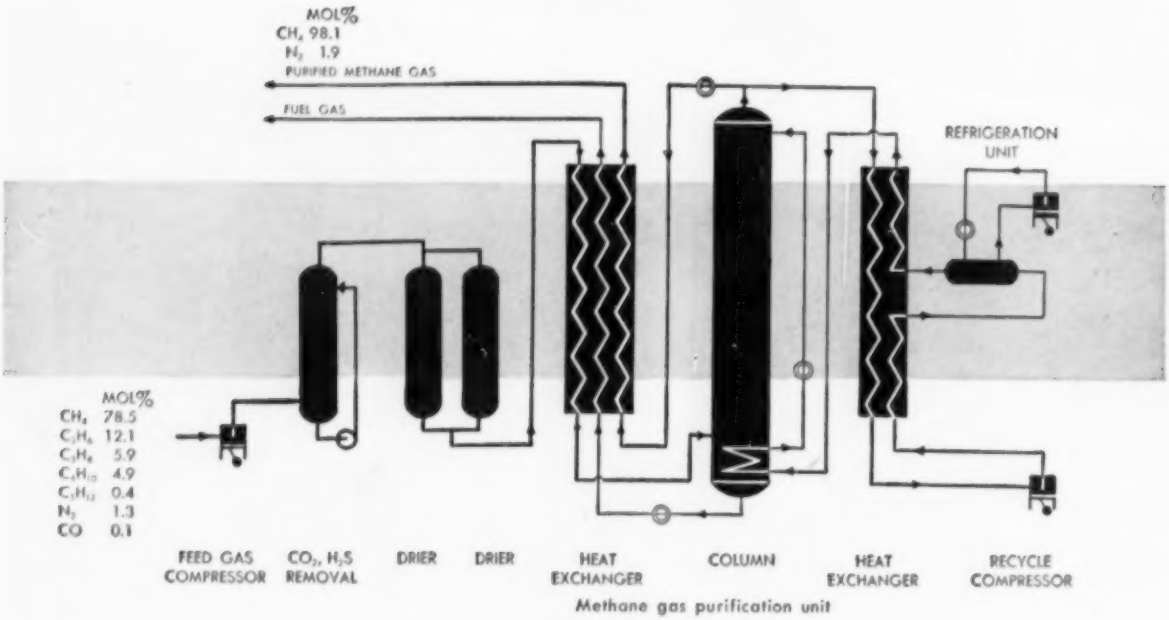
DYNAMIC DRYERS

CARBURETORS • BURNERS • FIRE CHECKS
METAL MELTING UNITS • INERT GAS GENERATORS
SINGEING EQUIPMENT

THE C. M. KEMP MFG. CO.
405 East Oliver Street, Baltimore 2, Maryland

practical approach to

METHANE PURIFICATION



Methane gas purification unit

In the production of chlorinated methane compounds and other chemicals based upon methane, the methane processed must be of ultra high purity. Air Products low-temperature processing plants—accepted as the most economical and practical approach—produce methane containing less than 100 p.p.m. of other hydrocarbons.

Air Products methane purification plants feature many cost-saving and special processing advantages:

- extremely high-purity methane, bone-dry and CO_2-free.
- valuable by-products—LPG, other heavy hydrocarbons, nitrogen.
- automatic control—requiring a minimum of labor.
- low power consumption.
- factory-assembled plants—assuring minimum installation expense.

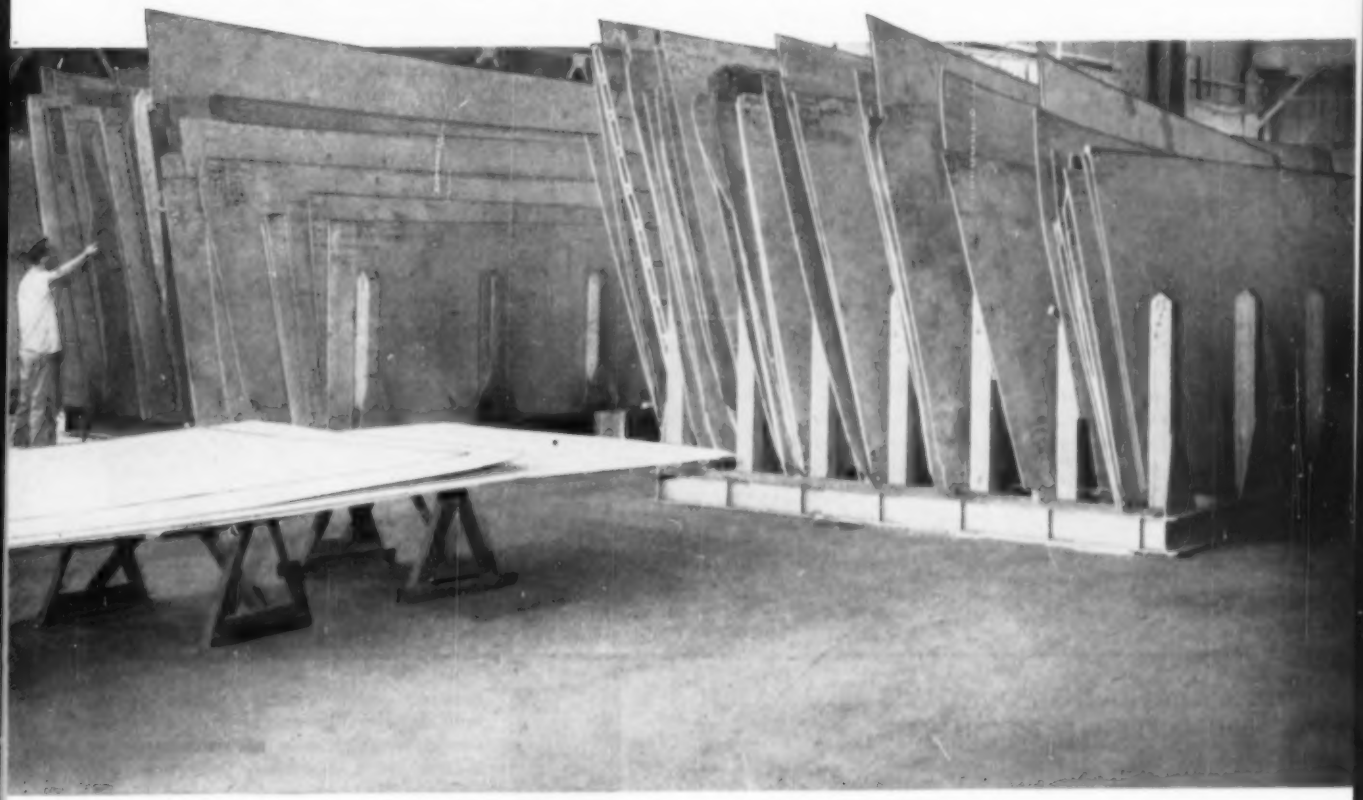
Many chemical plants are already using Air Products low-temperature equipment. In addition to the production of ultra high-purity methane, Air Products units are being used for the production of oxygen, nitrogen, argon and hydrogen . . . as well as the processing of natural gas, carbon monoxide, deuterium, fluorine and helium.

Here at Air Products, we design, manufacture, erect and operate . . . package, tonnage and custom-built industrial gas separation, liquefaction and purification systems. No matter what your requirements, Air Products will find a way for you to acquire or lease low-temperature equipment on mutually convenient and beneficial terms. Your inquiry is invited. Air Products, Incorporated, P. O. Box 538, Allentown, Pa.

Air Products
...INCORPORATED

Available now from Carlson

. . . any size and shape you want in Types 405, 410 and 430 stainless plate



Carlson's stock of Types 405, 410 and 430 chromium stainless plate is the largest ever. You can order plates, large or small, and get delivery in a few days. Types 405 and 410 find wide application in petroleum processing. Type 430 is generally used for furnace parts, annealing boxes and nitric acid storage tanks. Consider the 400 series if you need stainless plates right now.

Prompt delivery isn't your only advantage. These grades cost less than chromium-nickel stainless steels and if you need irregular shapes and sizes, experienced men with specially designed equipment can cut your plates and get them out in a hurry. Carlson provides a complete service with a flexible operation to take care of your specific requirements. This combination of stock, specialization and service saves you time and money, *gives you what you want when you want it!*

G.O.CARLSON *Inc.*

Stainless Steels Exclusively

THORNDALE · PENNSYLVANIA

District Sales Offices in Principal Cities

PLATES • PLATE PRODUCTS • FORGINGS • BARS • SHEETS (No. 1 Finish)

Noted and quoted

Commentaries by oil company executive Spaght and by the former Assistant Secretary for Defense (Research) Furnas on the subjects of . . .

TODAY'S ENERGY SOURCES . . .



Monroe E. Spaght | Shell Oil Company, New York City

A broad view of the earth's energy inventory shows two main kinds.

The first is replaceable energy. It is, or can be, regenerated; or probably will not be exhausted during man's term on this planet. It has been called income energy. It includes wood, water power, solar heat, tides, wind, steam from within the earth, and temperature differences in tropical waters. Almost all these come directly from solar radiation.

The other source of energy is irreplaceable. Once used it is gone forever. It has been called capital energy. Here we have the fossil fuels—coal, petroleum, natural gas, oil shale, and tar sands—partly degenerated organic matter accumulated among sediments in the earth's crust during the past 500 million years. Our capital energy sources also include the materials (such as uranium) used in nuclear energy.

The prudent individual likes to accumulate some capital, and he prefers to live within his income. But mankind is not living within his energy income. He is not even close to doing it. Potentially, the supply of income energy is enormous, but little is being done with it. Small progress has been made in harnessing tides. Wind, heat from natural springs, steam from within the earth—these offer rather limited local opportunities. The sun, of course, showers us with almost limitless energy. The earth's entire store of wood, oil, coal, natural gas, shales, and all the fissionable material we know about contains energy equal to about three days' worth of sunshine. We have only begun to see progress in capturing and using solar heat. The income energy is there, all right, but with our present technology, it costs more than we are willing to pay to get it. . . . So far, we have based our greatest advances on the use of fossil fuels. . . .

A pair of recent authors, in a study of energy, compared the earth—which they assumed to be about 2 billion years old—to a robust young man just reaching maturity. At about his sixteenth birthday, this young man began to store up energy; that is, the earth began to form deposits of coal, petroleum, oil shale, and natural gas. This took about five years. During the last year of this period, man appeared. And then something happened to use up the excess energy stored during the preceding five years. This corresponds to the intial stages of our machine age, in which we are burning up our fossil fuels. In the case of the young man, whose 21 years we equate with the earth's 2 billion, the burning will take about five minutes. We are living in that five-minute period. And just about the time our young man reaches maturity, he will be right back where he started—flat broke in the fossil fuel department.

Compared to the full span of time, the era in which man luxuriates in the flow of fossil fuels is brief. A curve showing the consumption of fossil fuels against a period of some thousands of years dramatizes this—the fossil fuel era is only a narrow, steep-sided pip in a long, flat line.

For the individual, the picture is different. There is little doubt that you and I will be able to take our last ride in a gasoline-powered vehicle. But if we are to exercise reasonable responsibility to our children and grandchildren, if we are concerned about stable economic and social development—and accordingly about the prospects for lasting peace—then we must look carefully into our use of fossil fuels and into the fuels that will replace them when they are gone.

Condensed from an address before the 1957 annual meeting of the Chinese Institute of Engineers, New York City.

. . . AND TOMORROW'S ENGINEERING PROBLEMS



C. C. Furnas | University of Buffalo, Buffalo, New York

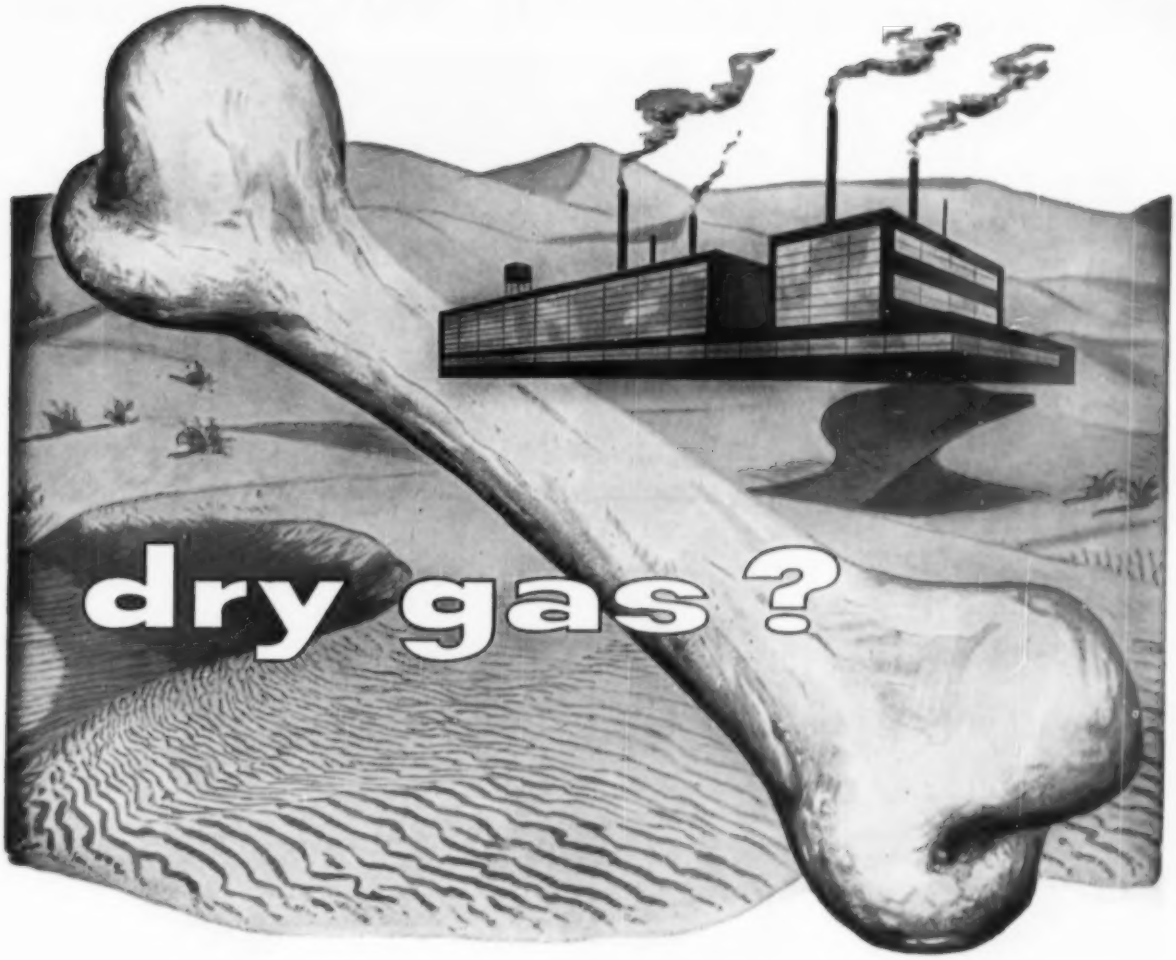
A great deal of intensive research is under way on controlled power production from fusion, i.e., the thermonuclear (hydrogen bomb) reaction. Though no practical method is yet in sight, the researchers are rather optimistic. Being an optimist myself, I feel that there is a good probability that we will be able to harness this thermonuclear reaction for practical purposes within the next generation. I feel that the basic research answers will have been obtained within the next decade. This, of course, is pure speculation, but I think that the history of past successes in difficult fundamental research lends substance to the optimism.

When we begin using nuclear power plants, there will be a tremendous amount of excess energy available in the form of neutron and gamma radiation which will be largely wasted, except as it appears in the form of heat. In all probability there are a number of chemical reactions which, by photochemical processes, could utilize the neutron and/or gamma radiation and store the energy in the form of chemical compounds, very much as the energy of the sun is stored in the chemical compounds of plants through the photosynthetic process. Perhaps some of these photochemical reactions could produce satisfactory liquid fuels from carbon dioxide and water, or other commonly available chemicals. Very little chemical research has been done along this line. It is my feeling that we should begin to find out what the possibilities are.

In his quest for minerals, man can look to the sea . . . Here, we have a great deal to learn from nature, because many of her organisms have evolved an art of concentration of minerals from sea water and have carried it to a high degree of effectiveness. Oysters, for instance, build up a concentration of copper on the interiors of their gelatinous bodies which is several hundred-fold greater than it is in sea water. Ordinary kelp (one variety of seaweed) builds up high concentrations of both potassium and iodine. Perhaps the gourmet does not care to think about it but the lobster

(*Continued on page* 34)

Condensed from an address before a meeting of A.S.C.E. at Buffalo, New York.

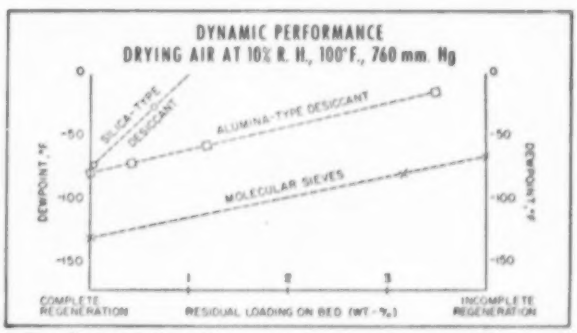


Now you can dry gases drier than dry!

LINDE Molecular Sieves can dry your gases—air, hydrogen, chemical streams—more thoroughly than any other commercial adsorbent. They will duplicate laboratory performances—*in your plant*—under normal *production* conditions.

Even though your gas stream may already be partly dried, Molecular Sieves will remove the last traces of moisture. Only a small volume of adsorbent is required. The same combination of high capacity and low dew-point is also obtained at high temperatures, up to 200°F.

This is SUPER-drying! Dynamic performance is shown in the accompanying graph. This superior performance also can be expected at higher relative humidities and at other temperatures and pressures. Of particular significance in production is the relative insensitivity of Molecular Sieves to incomplete regeneration.



For further information, write for data sheets on "Drying of Gases." Address Dept. CP-7, Linde Company, Division of Union Carbide Corporation, 30 East 42nd St., New York 17, N. Y.

The terms "Linde" and "Union Carbide" are registered trade-marks of UCC.

Linde TRADE MARK MOLECULAR SIEVES

UNION CARBIDE

In developing THERMOBESTOS Insulation



J-M at

Low Conductivity. The low thermal conductivity of Thermobestos is best demonstrated in actual service where it makes possible accurate, uniform temperature control, helps reduce fuel costs and contributes materially to operating efficiency.

Not damaged by water. Thermobestos has the moisture resistance outdoor service demands. Soak it in water for one day or 365—and you can still walk on it without damage. Dry it out and Thermobestos is as good as new, with conductivity and structural strength unimpaired.

Johns-Manville

for outdoor process industry applications

research scientists didn't stop top insulating effectiveness...



They added the three physical properties you most wanted— HIGH STRENGTH—LIGHT WEIGHT —MOISTURE RESISTANCE!

Thermobestos® offers the lowest k factor of all insulations in general use throughout the process industries. For maximum heat control on outdoor piping and equipment operating at temperatures to 1200F it just can't be beat!

Yet top insulating effectiveness is only one reason why more and more engineers are specifying Thermobestos for refineries, chemical plants, and wherever hot outdoor vessels and piping must be insulated. For Thermobestos also offers a threefold bonus . . .

. . . Three outstanding physical properties

Thermobestos is 1) strong and rigid. Its hard composition resists crushing and easily withstands unusual service abuse. Yet it is 2) lightweight for easy handling and fast application. And it is 3) highly moisture resistant, remains undamaged even by prolonged wetting.

Quickly, easily applied

Thermobestos is made from hydrous calcium silicate . . . molded to size for proper fit. Its high strength makes it particularly adaptable for time-saving shop prefabrication of fittings and bends.

Furnished in large sections, Thermobestos is easy to apply. It reduces the number of joints. In pipe insulation form, it comes in a complete selection of sizes up to 30" O. D. Also available in 6" x 36" and 12" x 36" blocks in a full range of thicknesses.

For further information write for your free copy of the 12-page Thermobestos booklet, IN-169A. Address Johns-Manville, Box 14, New York 16, N. Y. In Canada, Port Credit, Ontario.

INSULATIONS FOR LASTING THERMAL EFFICIENCY
MATERIALS · ENGINEERING · APPLICATION

JOHNS-MANVILLE JM PRODUCTS

JUST PLUG IT IN... AND START MULLING

SIMPSON Porto-Muller®



Low Cost
100% portable
Self-contained
Versatile
Efficient



POSITIVE MIXING ACTION. *Spring-loaded mullers permit easy adjustment of muller pressure—permits use of lightweight mullers, lets you adjust pressure to mull any material.*



FAST, SIMPLE DISCHARGE. *Just open the large bottom door and plows do the work. Door located at proper height for wheelbarrow. Automatic discharge makes unit virtually self-cleaning.*

The Simpson Porto-Muller is designed to fill a real need for a low cost—high efficiency muller in the 2½ to 3½ cubic ft. batch capacity range for the proper preparation of dry, wetted or plastic materials. As such, it is preferred for pilot plants and small production requirements. It's a versatile, efficient and completely self-contained mixer "package". With it you can duplicate the same high quality of mixing; realize the same mixing economies and be *assured* of the same rugged construction that has made the name Simpson Mix-Muller a standard of mixing quality for over 45 years.

Look over the outstanding features of this low cost mixer, then write for details on a free mixing report on *your* product. There is no obligation and remember . . .

MIXING AND THE INTEGRATION OF MIXING EQUIPMENT —IS OUR BUSINESS!



SIMPSON MIX-MULLER® DIVISION
National Engineering Company
652 Machinery Hall, Chicago 6, Illinois

Noted and quoted

(Continued from page 30)

has a concentration of iodine in its interior structure which is several hundred thousand times greater than that of the surrounding sea water. The slimy sea cucumber is a stupid and unattractive fellow but he is able to store up ten per cent of vanadium in his respiratory tract. This is many thousand-fold more concentrated than it is in the sea water in which he lives. If we understood the base-exchange and other selective processes which are going on in these low organisms, we might very well find practical ways of recovering large quantities of various minerals from the sea.

[Now, put these factors together] and visualize with me what might be done with an industrial complex built around a large nuclear power plant located on a seashore. Such an establishment, if organized in an appropriate manner, might operate profitably by producing the following:

1. Electrical power.
2. Liquid fuel, which would be produced by the photochemical reactions of neutron and gamma radiation on carbon dioxide and water, or similar materials.
3. Fresh water from sea water, which would be produced by a combination of electrochemical operations, diffusion, and evaporation which would utilize the waste heat from the nuclear reactor.
4. A number, say ten, of the valuable minerals which would be extracted from the sea water which had already been processed for its fresh water.

All this would require large and complicated apparatus, many parts of which we cannot visualize as yet; and it would call for an industrial organization which would be unique from our present point of view. However, the laws of nature and our technical competence might very well permit us to carry out such a consolidated operation on a practical basis.

. . .

I have tried to imply a feeling of urgency in my remarks. American industry has done very well indeed in the past, by waiting until problems were upon us before we began to solve them. We probably feel that we have been very practical in this matter because we have let other people do the worrying . . . However, this practical pattern of the past may be a very dangerous one for our future. If problems such as these are neglected, it will take a long time to solve them. If we are to maintain our industrial dominance, it would be well for us to have the solutions to some of the more severe problems in hand as soon as possible. . . .

ADVERTISEMENT—*This entire page is a paid advertisement* *Prepared by U. S. Industrial Chemicals Co.*

U.S.I. CHEMICAL NEWS

July ★ A Series for Chemists and Executives of the Solvents and Chemical Consuming Industries ★ 1957

Shredded Polyethylene Protects Electronic Brains

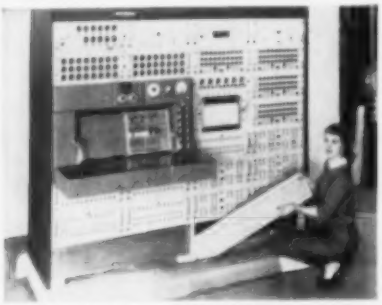
Special Form Supplied by U.S.I.

A self-charging electrostatic air cleaner, made of shredded polyethylene encased in a metal holder, protects the Goodyear Electronic Differential Analyzer (GEDA) from air-borne particles.

Shredded to present a large surface area to the air stream and to cause pronounced turbulence, the polyethylene generates an electrostatic charge which captures and holds dust, smoke and even pollen. Thus the air needed for ventilation in the electronic brain is free from the extraneous particles which might otherwise harm sensitive circuits.

These filters withstand air temperatures up to 212°F and are inert to chemicals normally encountered in industrial atmospheres. A special U.S.I. PETROTHENE® polyethylene resin is used, and is supplied in a form ready to be shredded instead of in the usual pellet form.

This particular polyethylene application is an example of how U.S.I.'s policy of tailor-making resins works in practice.



Secretary holds one of self-charging electrostatic air cleaners which protects analyzer.

Radiation Causes Decrease In Ability of Body to Absorb Methionine

New research indicates that the ability of experimental animals to make use of the essential sulfur amino acid, methionine, is impaired when the methionine is administered after exposure to radiation.

In the experiments, radiation from an X-ray source impaired the motor function of the digestive tract, causing delay in emptying the stomach and an increased rate of progression through the digestive tract. The progress of the methionine in the digestive tract of both the experimental and control animals was determined by tracer technique using methionine containing radioactive sulfur (S^{35}). Delayed absorption of methionine into the damaged tissues is thought to aggravate the digestive malfunctioning.

Previous research has shown that methionine given before exposure is effective in protecting against tissue damage caused by radiation. (U.S.I. CHEMICAL NEWS, Sept.-Oct., 1955.) These new findings indicate that methionine's action is largely protective rather than curative.

New Products, Packages Made 1956 Aerosol Industry's Biggest Year

Aerosol Hair Lacquers Become Sales Leader, CSMA Figures Show; New Glass and Plastic Aerosols Aided Industry's Growth

Results of the annual survey of the aerosol industry by the Chemical Specialties Manufacturers' Assn. show that 1956 was the biggest year yet for the 10-year-old industry. Unit sales were 320 million units, an increase of 33% over 1955, and 73% more than the 185 million units turned out in 1954.

Contributing to the upswing was the sharp sales rise of aerosol hair sprays. A relative newcomer to the field, hair sprays have even outdistanced insecticides in the race for top sales spot.

In the category of "Hair Lacquers", CSMA reported 1956 sales of nearly 80 million units. This figure is 25% of total sales for the industry.

Indications of the forward strides made by aerosols in the hair spray field had been apparent for some time; the Alcohol and Tobacco Tax Division of the Internal Revenue Dept. reported that last year 2,541,000 wine-gallons of alcohol went into hair and scalp preparations. This compares with 1,662,000 gallons for 1955, an increase of 51%.

While much of this alcohol went into hair and scalp preparations other than aerosol-packaged sprays and lacquers, it had been evident to industry observers that the aerosol market accounted for the bigger share of the gain.

New Packages Big Sales Factor

Influencing the upsurge in aerosol sales are such comparatively recent packaging innovations as the glass aerosol. Shampoos, perfumes, colognes, deodorants, suntan oil and other toilet preparations are now available in packages that combine the eye appeal of transparency with the convenience of the pushbutton dispenser.

In many cases, the desired safety factor is achieved by encasing the glass container in an attractive outer container molded of polyethylene. This plastic is also used almost exclusively for aerosol valves.

Thus, two U.S.I. products, ethyl alcohol and polyethylene, have played an important role in the phenomenal growth of the aerosol in

MORE



A variety of container designs has helped build the aerosol industry to its present strength.

U.S.I. Offers New Brochure On Zirconium and Hafnium

A new technical brochure which describes application and fabricating techniques for zirconium and hafnium has just been published by U.S.I.

In 12 pages, "Zirconium and Hafnium" provides technically minded readers with up-to-date information on properties, fabrication and uses in the nuclear and chemical processing industries. The brochure may be obtained by writing to U.S.I. at 99 Park Avenue, N. Y.

New Dibasic Acid Yields Water-White, Monomeric, Low-Temp Plasticizer

Hazen color tests on three monomeric, low-temperature vinyl plasticizers made with three different aliphatic dibasic acids and the same alcohol reveal that "U.S.I. ISOSEBACIC"® acid imparts by far the least color. A plasticizer made from synthetically produced ISOSEBACIC acid gave the low color reading of 150. Plasticizers made from the other dibasic acids, both derived from vegetable or animal oils, showed higher color. One gave a reading of 175 and the other was so dark as to be beyond the Hazen color scale.

"U.S.I. ISOSEBACIC" acid, a unique synthetic acid mixture of three C_{10} dibasic acids (2-ethyl suberic acid, 2,5-diethyl adipic acid and sebacic acid), not only permits production of esters of very light color, but also imparts to end products excellent low temperature flexibility and non-volatility characteristics expected of a material of this chain length. Isosebacate esters can be made at much lower cost than the corresponding normal sebacate esters.

"U.S.I. ISOSEBACIC" acid also shows promise as an intermediate for polyurethanes, nylon, polyesters, and high-temperature jet lubricants.

Sodium Dispersions Can Now Be Made Continuously

A new process for the continuous production of sodium dispersions has been developed and tested by the U.S.I. Research Department. For many processes, continuous preparation can provide higher production rates than conventional batch preparation.

MORE

ADVERTISEMENT—*This entire page is a paid advertisement* *Prepared by U. S. Industrial Chemicals Co.*

July ★ **U.S.I. CHEMICAL NEWS** ★ 1957

CONTINUED Sodium Dispersions

The design—including suggested equipment and procedures—is available to processors who are experimenting with the use of sodium dispersions on a production basis.

Details are given in a new U.S.I. brochure, "Sodium Dispersions." Pertinent up-to-date information is included on all aspects of sodium dispersion technology. A copy is available on request. Detailed design information for a particular continuous sodium dispersion set-up can be developed by working with U.S.I.'s technical service engineers.

CONTINUED Aerosols

dustry. Anhydrous ethyl alcohol is virtually a universal ingredient in hair aerosol formulations, and is widely used in other cosmetics now sold in aerosol form. Polyethylene, as already noted, is an important packaging component. U.S.I. provides nationwide distribution of these products, and technical assistance on their use.

Further Advances Seen

Aerosol industry leaders predict a continued rise in the sales curve. One of the largest makers of propellants forecast recently that unit sales of aerosols may well reach 600 million units by 1960.

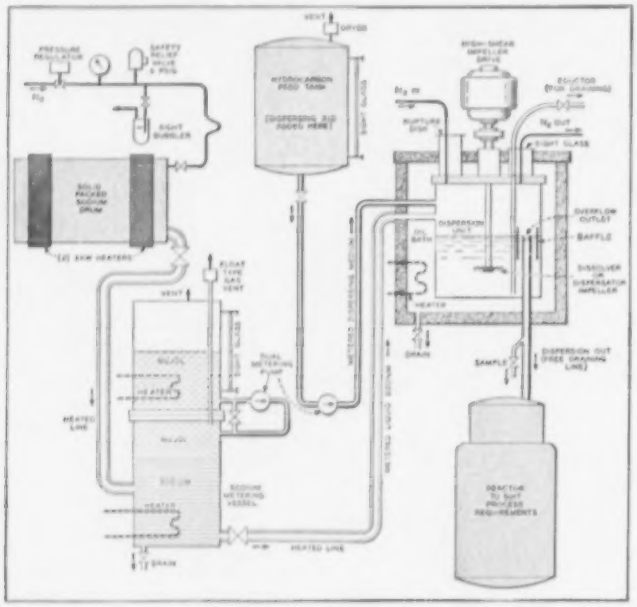


Diagram of the layout recently developed by the U.S.I. Research Department for continuous preparation of sodium dispersions . . . a new method in which sodium and an inert hydrocarbon dispersing medium are continuously pumped into a preparation tank, agitated to the desired particle size, and the finished dispersion discharged at an equal rate.

TECHNICAL DEVELOPMENTS

Information about manufacturers of these items may be obtained by writing U. S. I.

A solvent synergist has been developed to upgrade general purpose cleaners. Said to be compatible with numerous solvents, to emulsify insolubles in water, and to be useable alone with water. Low in corrosive properties, volatiles, odor and cost. **No. 1250**

Flat non-curl photoprints now can be produced with a new chemical stabilizer, its manufacturer claims. Prints are said to show improved retouching properties, pliability and high gloss. **No. 1251**

Sodium amide dispersed in xylene now is available in 1, 2 and 5 lb. cans. Commercial production is reported planned, with concentrations of 50% solids or lower. Carriers such as xylene, benzene and toluene will be utilized. **No. 1252**

Polyethylene dropper bottles with close control of flow rate and drop size now are offered. Squeeze operated, they are said to be contamination proof and to eliminate need for bulb fitments. **No. 1253**

The chemistry of hydrocarbon petrochemicals and derivatives is the subject of a new book which can be purchased. Preparation, reaction, catalysts, equipment, new theory and developments are covered. **No. 1254**

A mold release for polyethylene, reported to be a relatively inactive parting agent, has been designed to cut down the stress crazing experienced in using some silicone releases. **No. 1255**

New precision splitters for sampling accuracy have been developed. For assay and microscopic work, they feature multiple chutes down to ⅛" wide, machined parts, elimination of traps. **No. 1256**

Beta Caryophyllene heads several sesquiterpene fractions now offered in commercial quantities by a major producer. Purity of fractions is said to range between 90% and crude. **No. 1257**

Automatic freeze-drying laboratory equipment, new type tray dryers, faster manifold-type freeze-dryers, and combination units are detailed in a brochure just published. **No. 1258**

Corrosion control in industrial and marine applications is the aim of a new system of primer and finish surface coatings based on polyamide reacted epoxy resins. Advantages claimed: adherence over wet surfaces, no under-film creep, toughness. **No. 1259**

PRODUCTS OF U.S.I.

ALCOHOLS

Ethyl Alcohol (Ethanol): Specially denatured — all regular and anhydrous formulas. Completely denatured — All regular formulas for industrial use, anti-freeze. Pure alcohol—USP 190°—Absolute, N.F., taxfree, taxpaid.
Butanol (Normal Butyl Alcohol): Latent solvent for nitrocellulose, solvent for ethyl cellulose, many resins, many syntheses.
Amyl Alcohol, Refined: Fine chemicals, pharmaceuticals.
Fusel Oil, Refined: Blend of amyl alcohols refined by chemical treatment, distillation.
Proprietary Denatured Alcohol Solvents: SOLOX® — General-purpose. FILMEX® — Special, authorized for certain industries. ANSOL® M — Anhydrous, special blend for lacquers, resins, etc. ANSOL® PR—Anhydrous, special blend with higher ester content and solvency for lacquers, resins, etc.

OTHER PRODUCTS

PETROTHENE® Polyethylene Resins
Inorganic Chemicals: Sodium, Chlorine, Caustic Soda, Sodium Peroxide, Sodium Sulfate, Sulfuric Acid, Phosphatic Fertilizer Solution (Wet Process Phosphoric Acid) Ammonia, Nitrogen Fertilizer Solutions, Ammonium Nitrate, Zirconium Oxide, Zirconium Tetrachloride, Hafnium Oxide, Hafnium Tetrachloride.
Esters, Ethers and Ketones: Normal Butyl Acetate, Dibutyl Phthalate, Diethyl Carbonate, Diethyl Oxalate, Ethyl Acetate, Ethyl Ether, Acetone, Diatol®.
Intermediates and Fine Chemicals: Acetoacetarylides, Dimethyl Hydrazine, Ethyl Acetoacetate, Ethyl Benzoylacetate, Ethyl Chloroformate, Ethylene, Ethyl Chloride, Ethyl Sodium Oxalacetate, U.S.I. ISOSEBACIC® Acid, Methyl Hydrazine, Sodium Ethylate Solution, Triethyl Aluminum, Trimethyl Aluminum, Urethan USP (Ethyl Carbamate).
Animal Feed Products: Calcium Pantothenate, Choline Chloride Products, Curbay B-G® 80, Special Liquid Curbay®, DL-Methionine, Niacin USP, Riboflavin Concentrates, Vitamin B_{12} and Antibiotic Feed Supplements, Vacstone® 40, Vitamin D_3, E and K_3 Products, Antioxidant (BHT) Products, U.S.I. Permadry Products (Sealed-in Vitamin A), Special Mixes.
Pharmaceutical Products: DL-Methionine, N-Acetyl-DL-Methionine, Riboflavin USP, Urethan USP, Intermediates.
Metals: Titanium, Zirconium and Hafnium Sponge and Platelets, and Oxide.

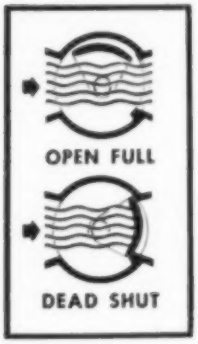
U.S.I INDUSTRIAL CHEMICALS CO.
Division of National Distillers and Chemical Corporation
99 Park Avenue, New York 16, N. Y.

U.S.I. SALES OFFICES
Atlanta • Baltimore • Boston • Buffalo • Chicago • Cincinnati
Cleveland • Dallas • Detroit • Houston • Indianapolis • Kansas City, Mo.
Los Angeles • Louisville • Minneapolis • Nashville • New Orleans
New York • Philadelphia • Pittsburgh • Portland, Ore. • St. Louis
Salt Lake City • San Francisco • Seattle

WHY RISK *Contamination* FROM *Lubrication?*



DeZurik Plug Valves eliminate the danger of contamination from valve lubricants. They operate easily, without lubrication—without "freezing"—with a quarter turn of the lever. No greases to stock, no fittings to buy, no gauges and guns to maintain. DeZurik Easy-Operating Non-Lubricated Plug Valves are complete in themselves.



ECCENTRIC ACTION

DeZurik Valves operate on an exclusive principle. The resilient-faced plug is pivoted eccentrically in the valve body and contacts the seat ONLY IN THE CLOSED POSITION! As the valve is closed, the plug is swung across and against the seat with a cushioned closure that seals tight despite solids in the flow. In opening the valve, the plug is backed away and to the side in an e-a-s-y quarter turn. No need to jack the plug loose with lubricants, no risk of contaminating the flow!

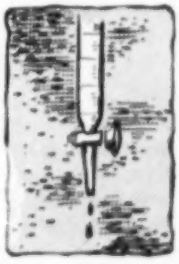
DRY SOLIDS

Because lubricants are not present in DeZurik Valves, granular material may be handled without special problems.



LIQUIDS

From the thinnest solutions to the thickest slurries, DeZurik Valves handle liquids without leakage, with a minimum of maintenance.



GASES

Lines handling gases under pressure present no problems for DeZurik Valves. The same dead-tight closure is obtainable.



For highly corrosive services, a full range of valve materials and special plug facings are available. Write for details.

DeZURIK CORPORATION
SARTELL, MINNESOTA

DeZurik Corporation
Dept. CEP-7
Sartell, Minnesota

Please send me more information regarding DeZurik Valves on (service)

.....

NAME .....
COMPANY .....
ADDRESS .....
CITY ..... ZONE .... STATE .....

Marginal notes

PREDICTING SCALE-UP RESULTS

Pilot Plants, Models, and Scale-up Methods in Chemical Engineering, R. E. Johnstone & M. W. Thring, McGraw Hill, New York, 307 p. $9.50.

Backeland's admonition to "commit your blunders on a small scale and make your profits on a large scale" appears to fit the evident purpose behind this new book by English authors. Representing an attempt to "systematize and present in a usable form such quantitative methods as are available for predicting the performance of large-scale process plant from small-scale experiments," the book draws on the precedent of established scale-up experiments as well as new developments in the study of behavior of existing full-sized plant units by means of (mathematical) models. Drawing again from the authors' preface, it is explained that although the book contains a fair amount of mathematics, it is believed easily intelligible. Moreover, most of the results are reduced to the form of simple scale equations which the authors intend to be directly applied to practical cases.

About one-third of the pages are devoted to a discussion of the principle of similarity, a review of dimensional analysis and differential equations, a discussion of the regime concept (regime being defined as the nature of the over-all rate-determining process in a system), similarity criteria and scale equations, and boundary effects ("every system has a boundary which separates it from its surroundings and delimits the variables which are under the experimenter's control").

Nearly half the book is devoted to chapters on equipment classifications. These include ducts and flow passages, filters, heat transfer equipment, packed towers, mixing equipment, chemical reactors, furnaces and kilns, mills, nozzles, atomizers, and extruders. Corrosion effects are dealt with briefly.

The last chapter deals with general theory and application of analog models, with several analogs for such cases as thermal radiation, transfer operations, fluid flow, etc. An extensive bibliography (270 entries) is included.

Progress—No Misnomer for Nuclear Energy

Progress in Nuclear Energy—Series II, *Reactors*. Edited by R. A. Charpie, Oak Ridge National Laboratory; D. J. Hughes, Brookhaven National Laboratory; D. J. Littler, A.E.R.E., Harwell; and M. Trocheris, C.E.A., Saclay. McGraw-Hill Book Company, Inc., New York; Pergamon Press Ltd., London (1956), 492 p. $14.00.

Reviewed by Herbert S. Isbin, Department of Chemical Engineering, University of Minnesota, Minneapolis, Minnesota.

Reactors is Vol. II of a series of eight volumes, called "Progress in Nuclear Energy," which are based primarily upon the papers presented at the United Nations Conference on the Peaceful Uses of Atomic Energy, Geneva, August, 1955. Vol. II contains an outstanding and comprehensive collection of nuclear reactor technologies and experiences in Canada, America, England, the U.S.S.R., and Europe. This wealth of practical information should be considered a counterpart to the Glasstone and Edlund "Elements of Nuclear Reactor Theory."

Most of the reactor papers in Vol. 2, *Physics: Research Reactors*, and Vol. 3, *Power Reactors* from the Geneva Proceedings are included. Essentially, the only new papers in the book are the summaries on research reactors presented by D. G. Hurst and A. G. Ward on the Canadian reactors; by J. Guéron on the European reactors; and by F. W. Fenning on the U.K. reactors. A catalogue of nuclear reactors is included also along with pertinent references. The quality of the Geneva papers is so uniformly outstanding that perhaps it is not a fair criticism to expect more than just a minor editing of the original papers for publication in this book.

As an illustration of the extent and the detail of the coverage, 41 pages are devoted to the discussion of the NRX reactor at Chalk River, Canada. The major topic headings include a brief historical introduction, reactor description, irradiation facilities, reactivity and its control, control and safety system, measurement of reactivity, characteristics (temperature coefficients, prompt poison, xenon poison, change of reactivity with operation), fuel element testing, research uses, and unusual occurrences. The latter topic contains references to stuck rods, fusing of uranium in a converter, failure of a plutonium-alloy rod, and the 1952 accident.

The book contains over 200 drawings and photographs, more than thirty tables, and is well documented with literature references. The efforts of more than twenty acknowledged experts covering the fields of design, construction, operation, and use of nuclear reactors have been combined to produce a volume which is strongly recommended to all who have an interest in the nuclear energy field.

Systematized Gas Dynamics

Elements of Gas Dynamics, H. W. Liepman & A. Roshko, John Wiley & Sons, Inc., New York (1956), 437 p. $11.00.

Reviewed by J. G. Tschinkel, Test Lab of ABMA, Huntsville, Alabama.

This book is an extension and modernization of an earlier publication by H. W. Liepman & A. E. Puckett, entitled "Introduction to Aerodynamics of a Compressible Fluid," published by Wiley in 1947.

The avowed intention of the authors is a presentation of the fundamentals of gas dynamics in the systematic fashion of a textbook, as it had grown out of teaching academic courses. Thus, the authors give preference to the elucidation of fundamentals instead of description of applications.

The material covered appears to be based primarily on the aerodynamics as occurring in the operation of supersonic wind tunnels. This fact may limit the usefulness of this book for chemical engineers.

The authors announce their intention of writing a second volume "more specialized, with particular emphasis on the aeronautical and missile field." This could, potentially, be more useful to chemical engineers.

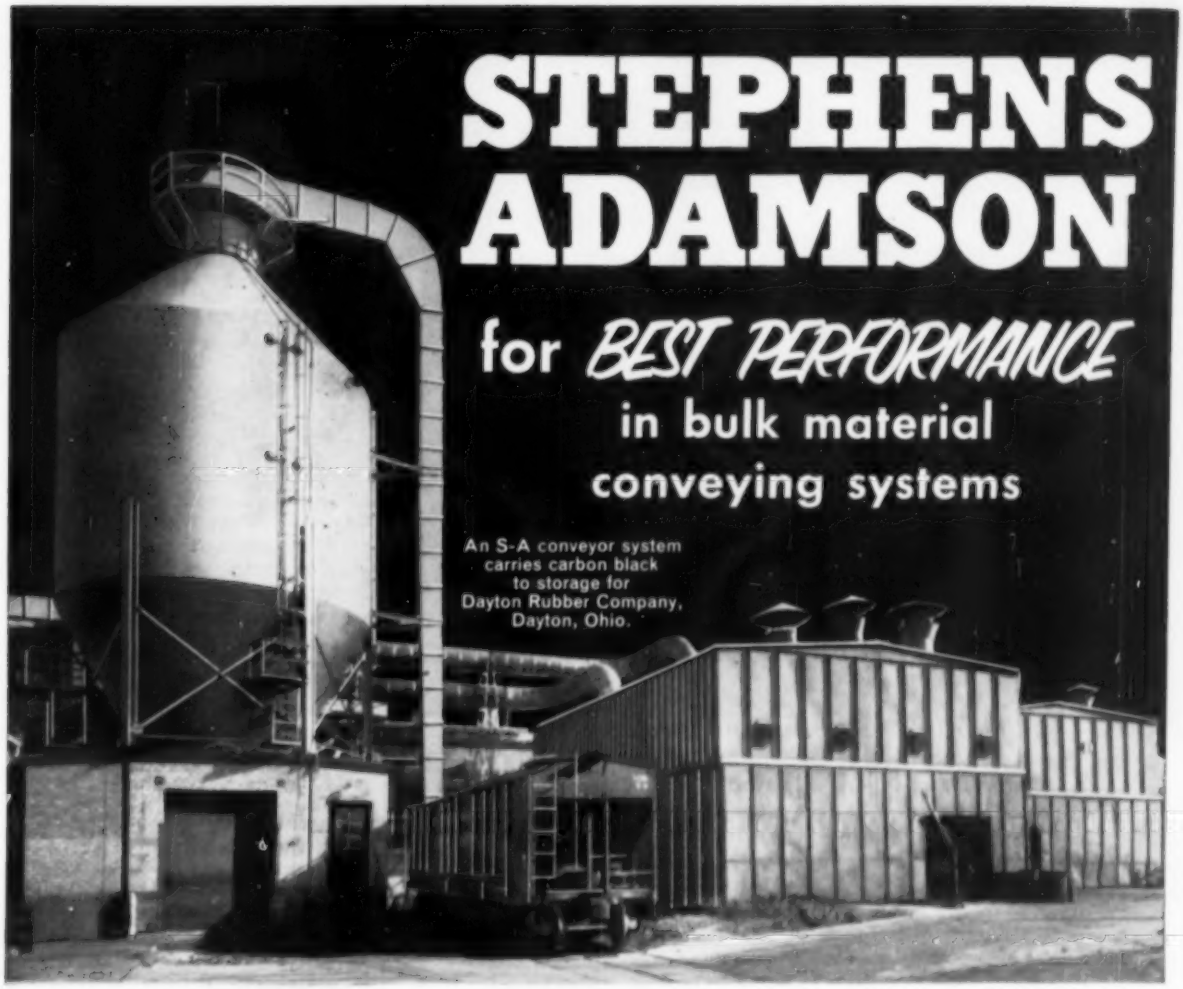
Within the frame of its intention, the book is excellently written, well organized, with numerous graphical illustrations, and calculation aids in the form of tables and graphs.

Chapters 1 and 14, entitled *Concepts from Thermodynamics and Concepts from Gas Kinetics*, respectively, are generally useful as concise and lucid refreshers on these subjects.

Of the remaining twelve chapters, one group treats the one-dimensional motion of gases, another group two- and three-dimensional motion. One chapter is devoted to methods of measurement as occurring in wind tunnel work. A chapter on transonic flow treats a newly introduced subject, not contained in the 1947 "Introduction."

STEPHENS ADAMSON

for *BEST PERFORMANCE* in bulk material conveying systems



An S-A conveyor system carries carbon black to storage for Dayton Rubber Company, Dayton, Ohio.



S-A zipper closed belt conveyor elevator requires no casing, operates over any plane. Automatically opens and closes, conveys any granular, flaky, pulverized or small lump material affording complete protection over any distance.

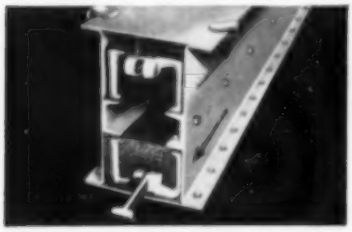
Reputation isn't bought—it's earned.

The reputation which goes with the big name of STEPHENS-ADAMSON has been earned by sound performance—over fifty years of it.

S-A systems serve the chemical processing industry often under most adverse conditions, delivering steady tonnages economically with minimum man power and maintenance effort.

S-A engineers fully understand the complexities of handling a great variety of chemical products. Their long experience permits swift and accurate solutions to any conveying problem.

Call the S-A sales engineer in your area for a "new look" at your conveying methods. His expert advice costs you nothing.



REDLER conveyors-elevators move material within an enclosed steel casing which is protective and dust tight. It conveys on horizontal or inclined planes, around corners, inside or out. It is compact, economical and easily erected.

STEPHENS-ADAMSON MFG. CO.

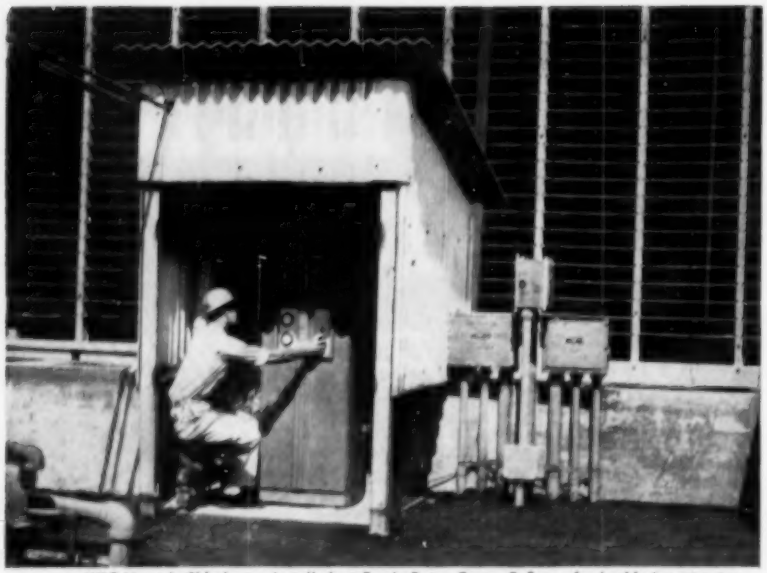
57 RIDGEWAY AVENUE, AURORA, ILLINOIS

LOS ANGELES, CALIFORNIA — BELLEVILLE, ONTARIO

S-A manufactures a wide range of material handling products in three complete plants in U. S. and Canada.

- Belt Conveyors
- Belt, Pan & Plate Feeders
- Ship Loading Boom Conveyors
- Stacking Conveyors
- Storage & Reclaiming Systems
- "Natural Frequency" Vibrating Conveyors
- REDLER Conveyor-Elevators
- ZIPPER Conveyor-Elevators
- Conveyor Belt Cleaners
- Headshaft Holdbacks
- Grizzlies & Screens
- Centrifugal Pilers
- Bin Gates & Tunnel Gates
- Car Pullers & Spotters
- Bucket Elevators
- Skip Hoists
- SEALMASTER Ball Bearing Units

• Write for a bulletin on any of the above products



W&T V-notch Chlorinator installed at Esso's Baton Rouge Refinery feeds chlorine at rates up to 500 lbs./24 hr. Units are available with chlorine capacities up to 2000 lbs./24 hr.

NEW W&T V-NOTCH CHLORINATORS,

used at Oil Refineries, are rugged, easy to operate and moderately priced.

Esso Standard Oil Co. has a W&T V-notch Chlorinator installed at their Baton Rouge, La., Refinery. The chlorinator, installed in a small shed open to the sun and weather, chlorinates cooling water for slime control.

This type of installation would be considered rugged service for other equipment but V-notch Chlorinators are designed for such use. They are made of materials that are completely resistant to corrosion as well as weather. They are simple to operate and to maintain. In addition, W&T V-notch Chlorinators are an attractive piece of equipment, colored green to fit into industrial color schemes.

For more information about W&T V-notch Chlorinators, send for bulletin CD-44.

WALLACE & TIERNAN INCORPORATED

25 MAIN STREET, BELLEVILLE 9, NEW JERSEY



HOW TO DETECT 3 PARTS CHLORINE IN A MILLION PARTS AIR

New W&T Solvay Chlorine Detector*

detects as little as 3 p.p.m. chlorine in a continuous air-stream sample. Automatically sets off alarm at higher concentrations.

Write for Publication 50.118

WALLACE & TIERNAN
INCORPORATED
25 MAIN ST., BELLEVILLE 9, N. J.

I-55 *Manufactured under patent license from Solvay Process Div., Allied Chemical & Dye Corp.

About our authors

V. L. Shipp, who writes on the young engineer in industry, is presently adjunct professor at Brooklyn Polytech, was for more than 25 years an oil company executive.

R. D. Wallen, a psychologist specializing in training people to work together in groups, is senior associate of Creelman Associates. Both the firm and Dick Wallen should be well known to readers of *CEP's* January '57 issue, which contained a special section on operations research. This issue, incidentally, is out of print.

Arthur Wrotnowski, who writes on non-woven filter media, has been since 1948 research engineer doing product development for American Felt. A California chemical engineer, Lt. Commander Wrotnowski served aboard *Wasp, Lexington,* and *Alaska* with toughest job assistant engineering officer during W.W.II. Commenting recently after having designed and built with little outside assistance an ultra-modern house, "the utilities network I installed is almost as complicated as that of a battlewagon. . ."—which makes us wonder, what *did* he install?

Donald A. Dahlstrom, director of development for Eimco (filter manufacturers) is currently in Europe, demonstrated his loyalty to A.I.Ch.E. by reviewing a manuscript while on the trip across the Atlantic. Formerly on the chemical engineering staff at Northwestern, Don has made an enviable reputation in the advancement of the theory and practice of filtration. **P. A. Nelson,** co-author, made the investigation reported in the article at Northwestern, and with the aid of a large amount of data made available by Eimco.

R. J. Corruccini of the Boulder Cryogenic Laboratories of the Bureau of Standards was introduced to *CEP* readers last month, when the first in the series of three articles on properties of materials at low temperatures appeared.

R. L. Hershey (*Management Cost Accounting*) is general manager of Du Pont's Polychemicals Department. **C. R. Schwartz** is now deceased, was control manager, for many years

(*Continued on page* 44)



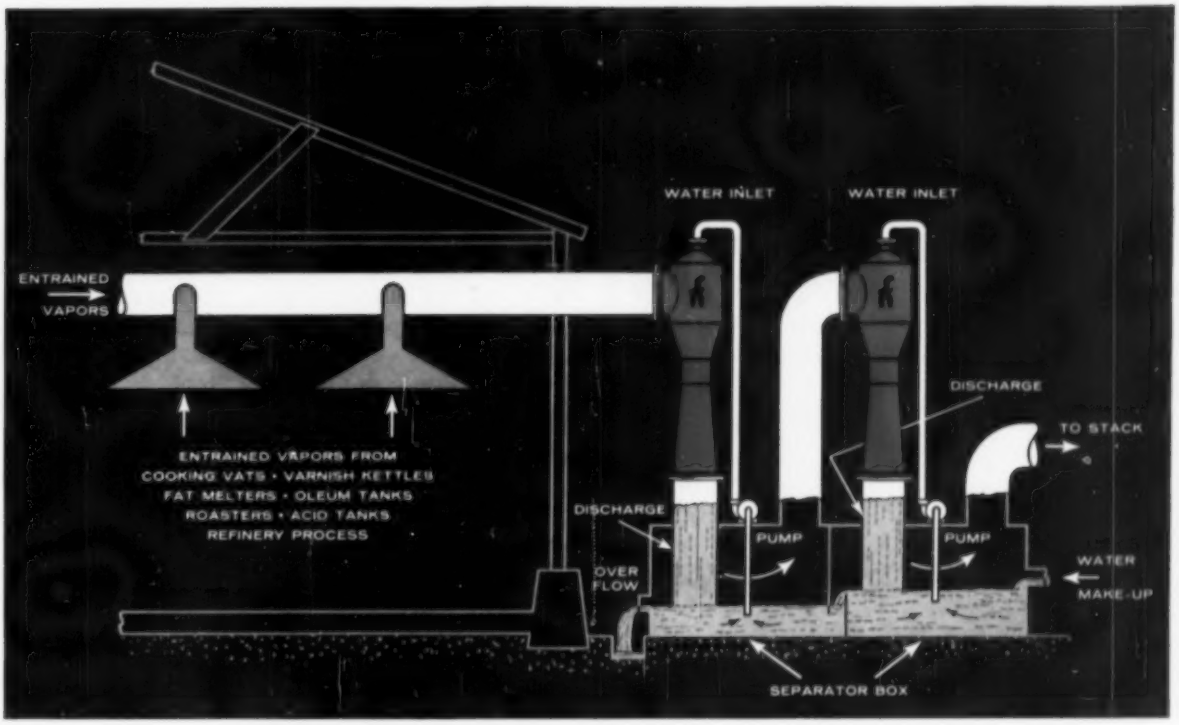
Dahlstrom



Hershey



Crichley



CONTROL OBJECTIONABLE FUMES, GASES, VAPORS

with an economical SK Fume Scrubber

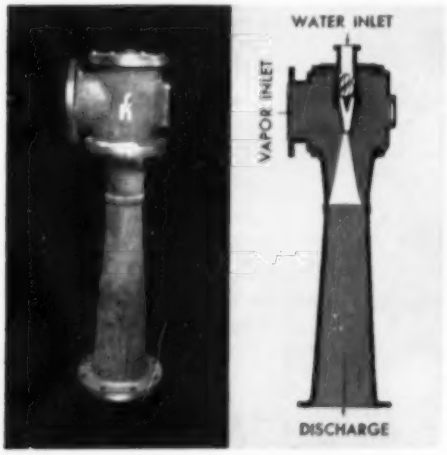
A food plant in California uses an SK Fume Scrubber to condense steam and scrub oil vapors from cooking vats. A large chemical manufacturing plant on the eastern seaboard uses a battery of SK Fume Scrubbers to condense steam and purge entrained gas containing H_2SO_4, SO_2, H_2S, TiO_2, and ore dust. A mid-western manufacturer uses SK Fume Scrubbers to vent oleum tanks. A soap maker in Pennsylvania uses a scrubber to remove ammonia fumes from a plant building and cool the building at the same time.

From coast to coast, chemical and food processing plants, refineries, paint and varnish manufacturers, fertilizer, and other manufacturing plants are using SK Fume Scrubbers to control objectionable—sometimes dangerous—fumes, gases, vapors, and dusts.

These manufacturers have found that SK Fume Scrubbers are reasonably low in initial cost, require little maintenance, and are an effective means for conforming to local ordinances which prohibit the pollution of air.

Made in a wide range of sizes from cast iron, steel plate, Haveg, stoneware, or other materials or with linings of rubber or Polyvinyl Chloride, or other synthetic materials, SK Fume Scrubbers can help you solve a fume or dust problem. Why not get the whole story. Send for Bulletin 4R which contains complete information on SK Fume Scrubbers.

Photo and sectional drawing of an SK Fig. 4010 Fume Scrubber



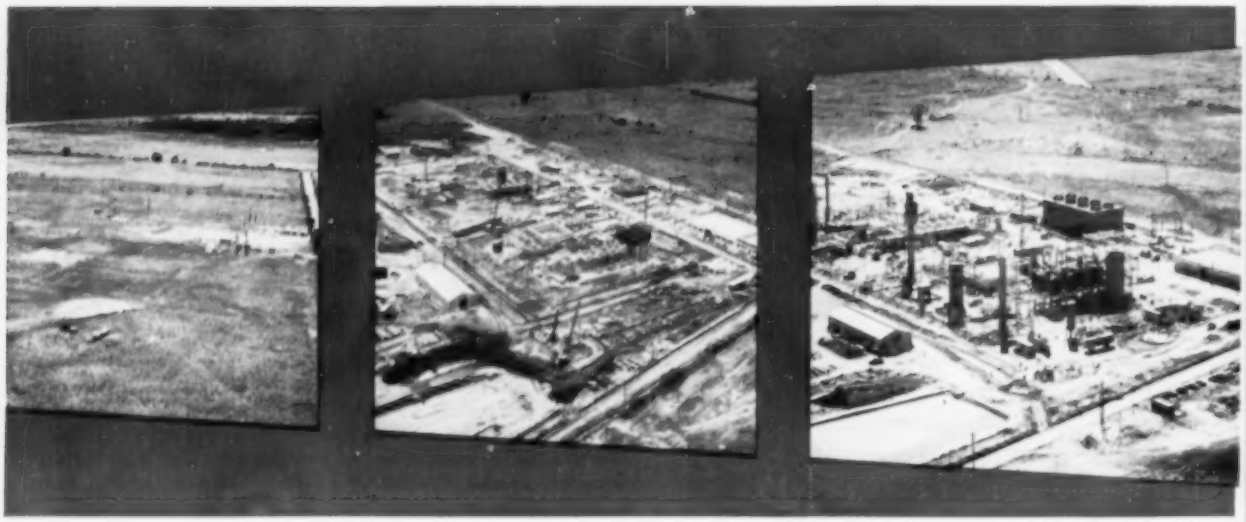
JET APPARATUS: Ask for Condensed Bulletin J-1.
ROTAMETERS & FLOW INDICATORS: Ask for Condensed Bulletin 16-RA.
VALVES: Ask for Condensed Bulletin V-1.
HEAT TRANSFER APPARATUS: Ask for Condensed Bulletin HT-1.
GEAR PUMPS: Ask for Bulletin GT-A.

Schutte and Koerting
COMPANY
MANUFACTURING ENGINEERS SINCE 1876
2245 State Road, Cornwells Heights, Bucks County, Pa.

FORESIGHT BY

Firestone

With world-wide rubber consumption at an all-time high, Firestone, the world's largest rubber producer, planned ahead to expand production of FR-S, Firestone's new high-quality synthetic rubber. A major step in the giant expansion program is the modern Butadiene plant at Orange, Texas, to supply basic raw material. For engineering and construction, Firestone called on CATALYTIC.



JUNE 26, 1956 AUGUST 28, 1956 OCTOBER 30, 1956

CATALYTIC
CONSTRUCTION COMPANY
Philadelphia 2, Pennsylvania • Toledo, Ohio

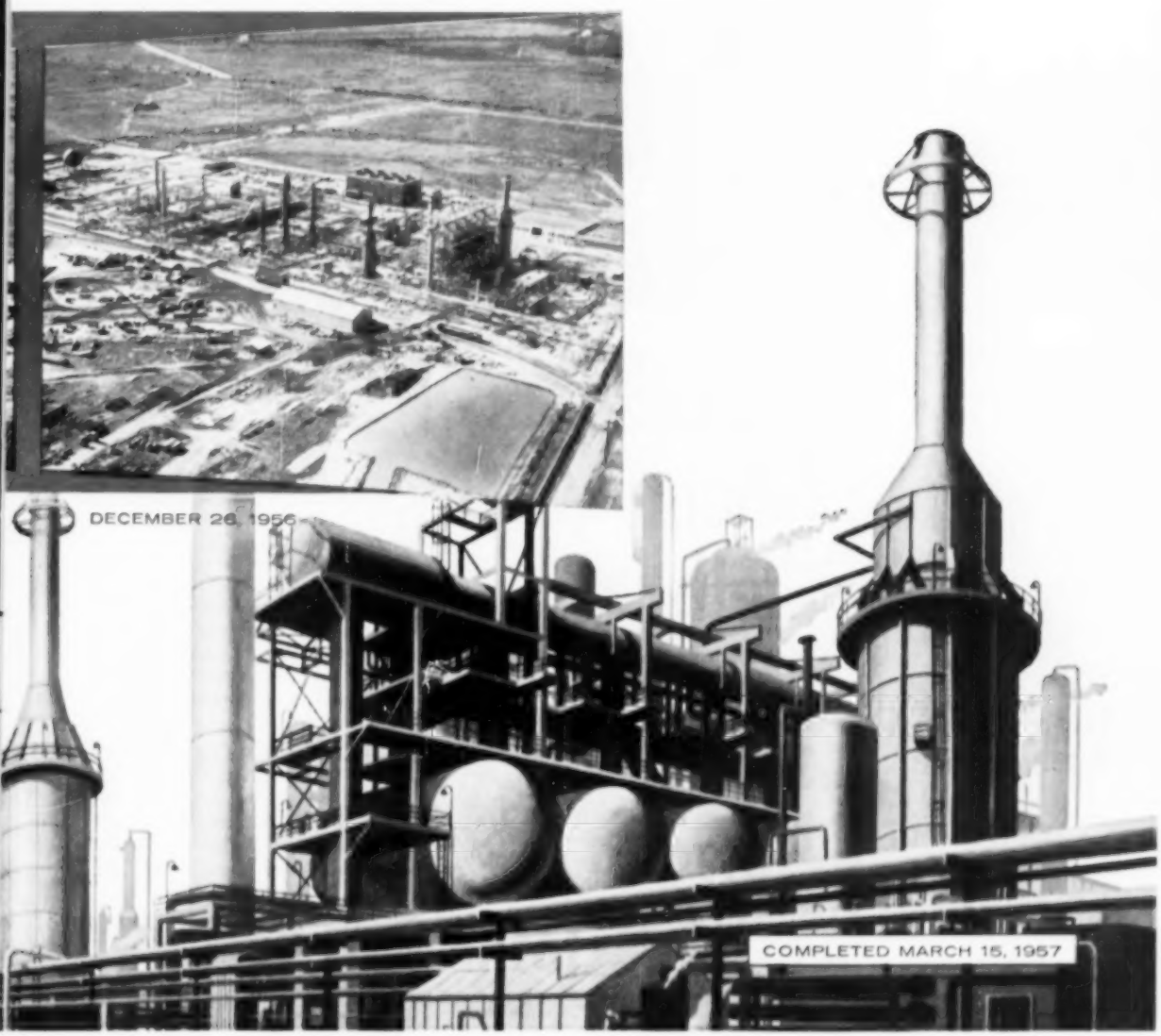
In Canada:
Catalytic Construction
of Canada, Limited
Sarnia, Toronto, Montreal

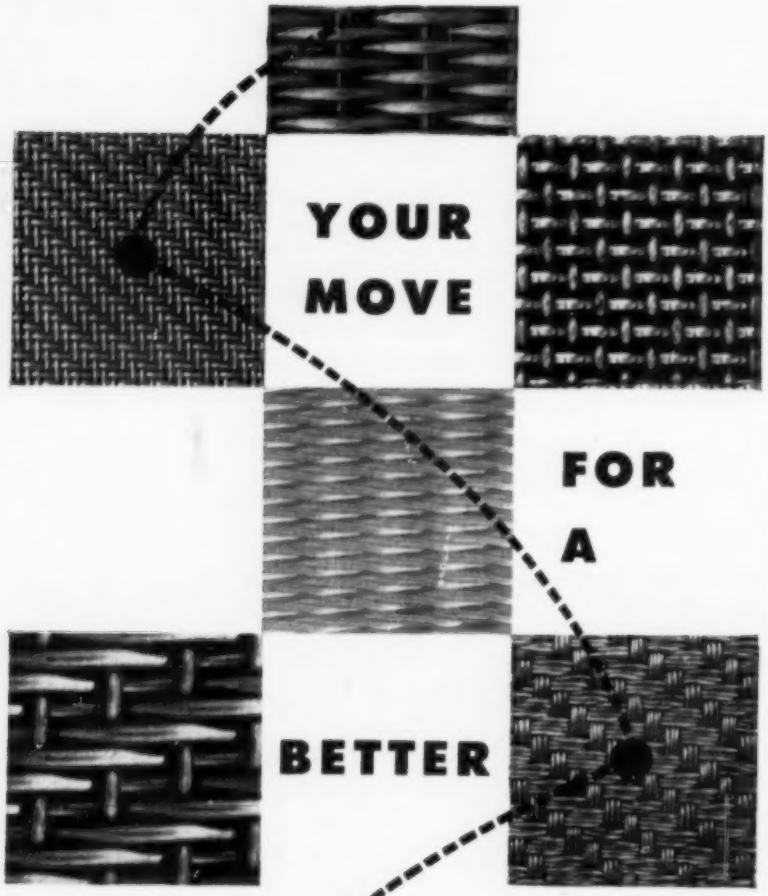


PERFORMANCE BY CATALYTIC

Construction started—June 26, 1956
Plant completed—March 15, 1957 (less than 9 months in the field)

This outstanding performance clearly demonstrates the worth of undivided responsibility which enabled CATALYTIC to complete process design, engineering, procurement and construction of this multimillion dollar facility . . . on time and on budget.





Metallic Filter Cloth

NEWARK for ACCURACY

For the most uniform, most accurate metallic filter cloth, specify NEWARK. All weaves, all metals for all types of service, there's a NEWARK filter cloth engineered to meet your requirements. Send for our New Catalog E.

Newark Wire Cloth COMPANY

351 Verona Avenue • Newark 4, New Jersey

About our authors

(*Continued from page* 40)

pioneered in application of electronic accounting machines then novel to Du Pont as well as other companies.

W. A. Crichley is controller of Diamond Alkali Co., has served in various capacities in the Controller's Institute of America and on tax committees of Manufacturing Chemists' Association. Crich feels that speedup of customer service is a standing challenge to basic chemical producers and is gratified that his I.D.P. system is moving tank cars more rapidly and with less paper work.

F. B. Hutto, Jr., is a member of the Celite Division research group at the Johns-Manville research center in Manville, N. J. He is a Ph.D. from Cornell.

W. R. Marshall, who with **E. J. Crosby** (DuPont) authored the work on spray drying, writes: "At the present, I feel my most useful contribution in spray drying is the A.I.Ch.E. Monograph which was based on the 4th Institute Lecture. This plus receiving the Walker Award have been highlights in my career." Bob, now a director of the Institute, looks back fondly over the years he has been conducting graduate studies at Wisconsin in the field of atomization and spray drying, can count proudly the sizeable numbers of Wisconsin men who have continued their professional careers in the field.

Joseph Kolberg is project chemical engineer for the Ketchikan Pulp Co., Ketchikan, Alaska. In commenting on his article about stainless steel vs. corrosion in a pulp mill, he writes: "Our most important discovery, generally speaking, was the determination that the present specifications for stainless steels—especially type 316—are too liberal. If through this work and its publication we manage to alert others to this, then something important will have been contributed to the field of corrosion."

Norman Ketzlach is a chemical engineer who received his early experience in the atomic energy field as a member of the Separations Technology Section at Hanford. At present

(*Continued on page* 46)


Hutto


Marshall


Ketzlach

No Excessive Heating

New Rectifier Cooling System Prevents Heat Build-up and Damage

when ac Power Fails

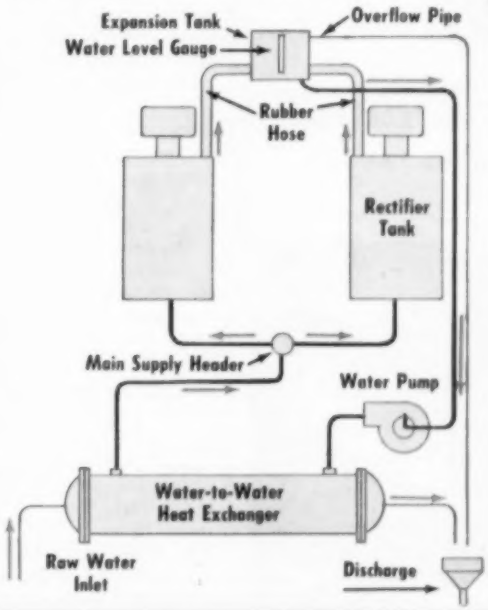
A SAFER, more effective cooling system in the Allis-Chalmers rectifier continues to circulate water *even when an ac power failure stops the water pump.* Heat and steam are dissipated before they can develop to the danger point.

The new system features an expansion tank that extends the full length of the rectifier frame with short vertical connections from each tube. With warm water continuing to flow freely upward, a thermo-siphoning action draws cooler water into the tubes. Build-up of excessive temperatures is prevented. Steam pockets are kept from forming. Subsequent water loss from the recirculating cooling system is minimized.

Successful operation in hundreds of installations is your assurance of the complete reliability of Allis-Chalmers mercury arc rectifiers. Contact your nearby A-C office or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wis.

How the System Works

Water is normally pumped through the water-to-water heat exchanger to the main supply header from where it circulates through rectifier tubes picking up heat. Hot water flows up through the short connections to expansion tank and back down to suction side of water pump.



ALLIS-CHALMERS
Mercury Arc Rectifiers



Factory-packaged units cut installation time and costs. Sealed tube rectifiers are supplied in completely enclosed or open types. Here is a typical, completely enclosed, 1000-kw, 250-volt rectifier for steel mill service.

ALLIS-CHALMERS

A-5425

MORE GALLONS

If your liquid moving problem is primarily a matter of pumping efficiency . . . more gallons per kilowatt hour . . . then you should get the facts about Ingersoll-Rand's line of Motorpumps.

Its high efficiency results from a well-designed and expertly finished impeller and casing . . . carefully selected for each job from the most extensive line available . . . a good stuffing box or mechanical seal . . . and the best brand name motors.

In addition, the powerful Motorpump is built for long life, low maintenance and operating dependability. Get complete information by contacting the local Ingersoll-Rand branch office or write for a complete bulletin.

MOTORPUMP

by

Ingersoll-Rand

11 Broadway, New York 4, N.Y.



Sizes ¼ to 75 hp
—capacities to 2800 gpm
—heads to 650 feet

9-591

About our authors

(*Continued from page* 44)

he is a specialist in nuclear safety where he applies the principles of nuclear physics in the design and operation of reactor fuels manufacturing facilities as well as reactor fuels processing plants.

A. G. Eickmeyer was with J. F. Pritchard Co. of Kansas City when he authored the article on "Which Way to Hydrogen?", is now a consultant. He feels his most important contribution is the development of correlation of reform furnace performance in terms of operating conditions, outlet gas composition, tube wall temperature, and tube dimensions. This correlation, together with a rigorous design method, is said to permit optimization of equipment parameters for any specific application. He says further that his correlation was developed from an analysis of furnace performance obtained with such a poor catalyst that the data would ordinarily have been regarded as worthless.

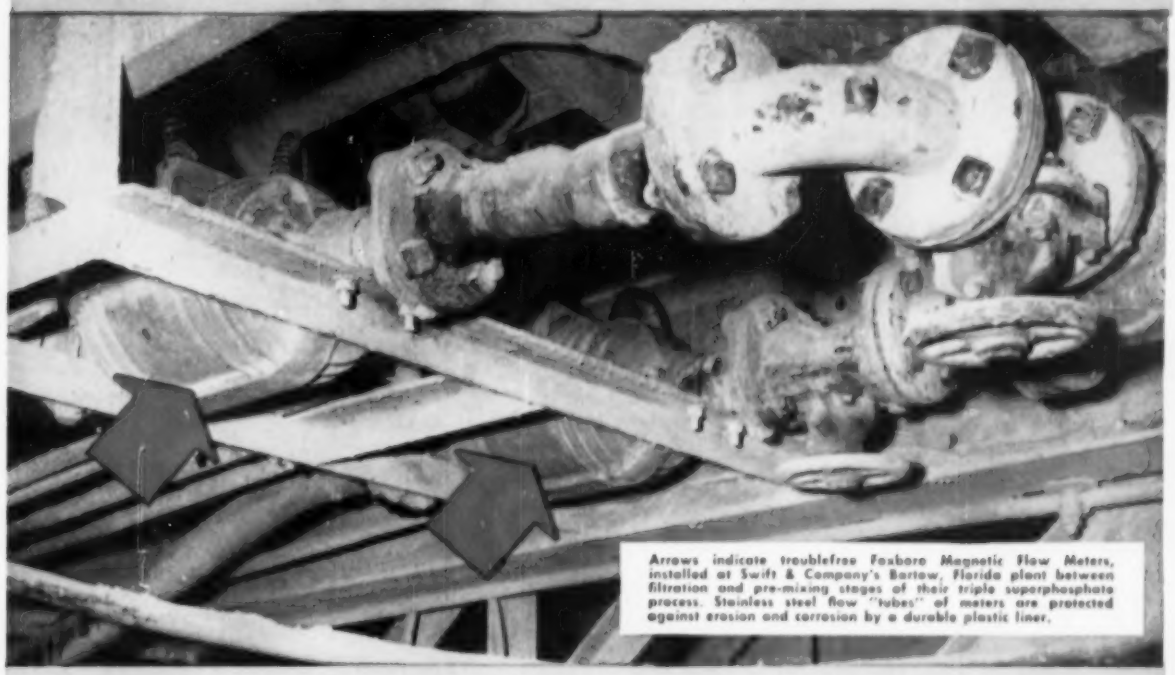
Noted and quoted

(*Continued from page* 16)

pany depends, as does the job itself, upon personal make-up. Some employees are happier in a country environment; others prefer urban sophistication. In large companies one obtains better organization of training and more job security, but runs into more regimentation and red tape. If in the final analysis one has in mind a business of his own, it is likely that the small company will provide a better opportunity for the engineer to learn broader aspects of the business and therefore it will offer a better preparation.

Another point to stress—one of paramount and immediate importance—is the desire, natural enough, to make fast progress in employment. Promotions depend upon speed in learning the trade, and this training, as indicated previously, is administered by a senior fellow on the job. In a new job situation, if preliminary discussions with fellow workers and supervisors are satisfactory, if a spirit of comradeship and of teamwork is noted this is probably the right connection for a young engineer maturing into an adult life of profitable responsibility. It is suggested that the engineer or any other prospective employee looking toward promotion reject the offers with higher initial salary unless the environment passes this simple test.

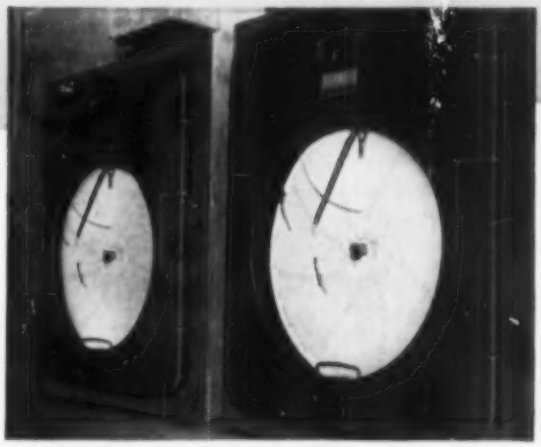
"Ornery" Phosphate Slurry Metered as Easily as Water!



Arrows indicate troublefree Foxboro Magnetic Flow Meters, installed at Swift & Company's Bartow, Florida plant between filtration and pre-mixing stages of their triple superphosphate process. Stainless steel flow "tubes" of meters are protected against erosion and corrosion by a durable plastic liner.

...by Foxboro Magnetic Flow Meters at

Swift & Company



By watching slurry flow rates on Dynalog Recorder charts, operators precisely regulate feed of H_2SO_4 to the reactor tanks . . . permitting better quality control right down the line.

Measuring slurry is duck soup for two Foxboro Magnetic Flow Meters now used in the production of Swift & Company's Agricola plant food. Here's the story.

The company was shooting for uniform pre-mixing and quality control. Needed was an accurate means of measuring the flow of partially filtered phosphoric acid slurry. Orifice plates, or anything that restricted flow, eroded. Pressure taps quickly fouled. Even *purged*, long-cone Venturi tubes plugged! Solution? *Electrical* measurement with Foxboro Magnetic Flow Meters. Their smooth, pipe-like interiors simply *ignore* the suspended phosphate solids. There's no erosion, no fouling. Two flush-mounted electrodes "pick up" flow measurement . . . Foxboro Dynalog* instruments record it directly on a linear scale chart. And these records are accurate to 1% of full scale!

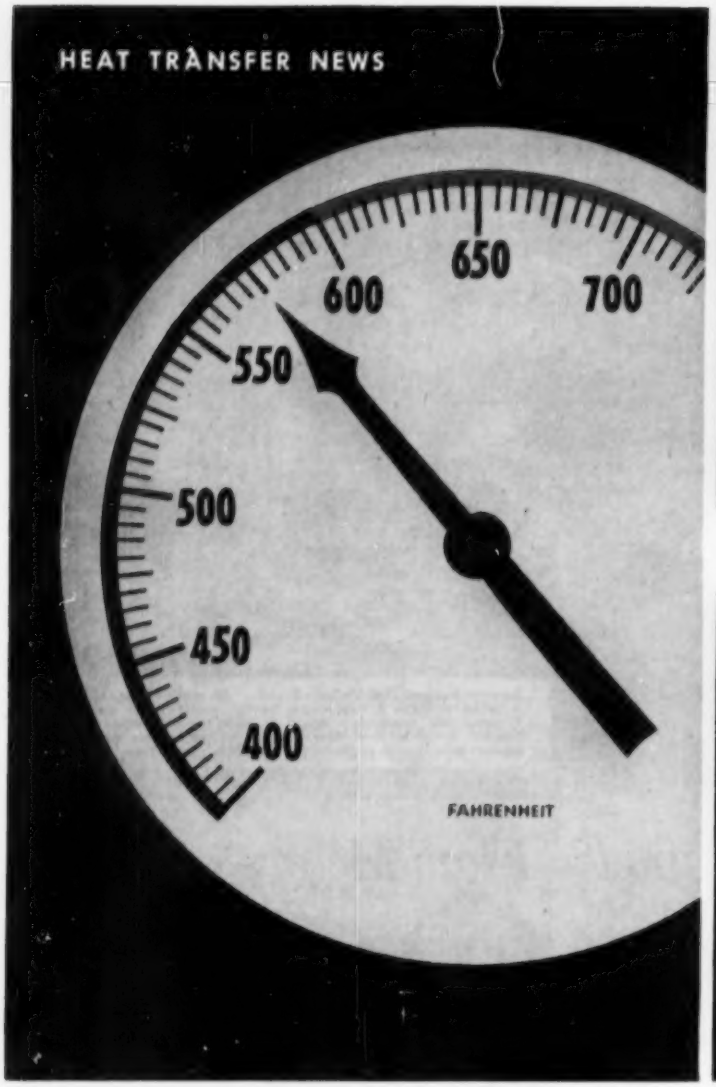
Find out exactly how the Foxboro Magnetic Flow Meter works . . . how it can efficiently and accurately meter the "impossible" in *your* plant. Write **The Foxboro Company, 937 Neponset Avenue, Foxboro, Mass., U. S. A.**

*Reg. U. S. Pat. Off.

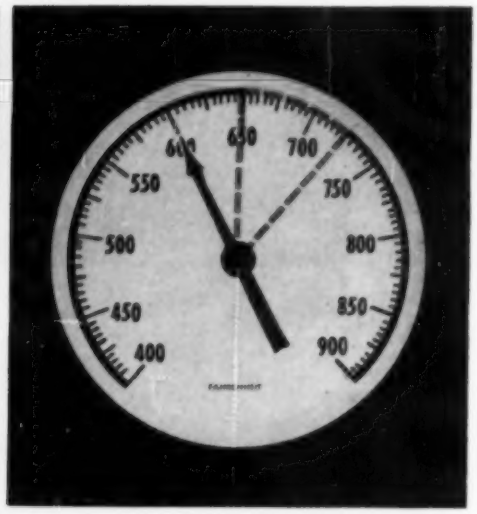
FOXBORO

REG. U.S. PAT. OFF.

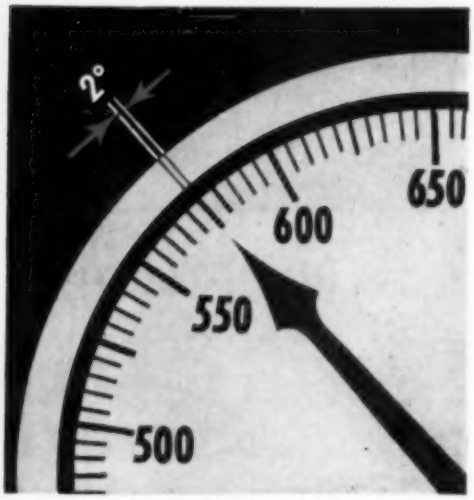
MAGNETIC FLOW METERS



Continuous operating temperature up to 600° F.



Boiling range 652° to 725° F.—assures liquid at all times.



Pin-point control within 2° F.

Write Monsanto for sources of heating systems using Aroclor 1248 . . . a non-pressurized, liquid-phase, heat-transfer fluid

Aroclor 1248 is a new kind of heat-transfer fluid that's fire-resistant and operates at atmospheric pressure.

The Equipment . . . Capacities can range from small portable units, usually electrically heated, to large gas- or oil-fired units generating from 250,000 to over 10,000,000 B.T.U.'s per hour. Circuits are closed, forced circulation. Compact design saves space, minimizes installation and maintenance costs.

The Fluid . . . Aroclor 1248 is a highly stable chlorinated polyphenyl; does not support combustion up to its boiling range 652° to 725° F.; has autogenous ignition temperature of extremely high 1299° F.; is non-corrosive. Aroclor 1248 operates in most systems four to seven years without replacement.

Monsanto will send you a list of designers and manufacturers of Aroclor 1248 equipment. Write today.

AROCLOR: Reg. U. S. Pat. Off.

Organic Chemicals Division
MONSANTO CHEMICAL COMPANY
Dept. IF-72, St. Louis 1, Missouri

MONSANTO

WHERE CREATIVE CHEMISTRY WORKS WONDERS FOR YOU

There is an increasing number of signs of a changing industrial climate as regards business, in spite of the fact that the National Administration is Republican and therefore traditionally favorable to business. One criticism of the former Democratic administration made in business circles was that it created an uncertain climate which did not contribute to the confidence of industry in the future. The election of a Republican administration was hailed in financial and industrial circles as a different sort of "new deal" in which business might legitimately go ahead without the fear of unexpected harrying from Washington.

However, now that another election draws near, there are signs of coming attacks on business in Washington—especially in Congress—partly as a means of making political capital and campaign material. What form these activities may take is naturally still difficult to say definitely and while there is no particular reason for alarm, in an election year this sort of thing may well be expected.

One thing that seems probable is continued attack on "bigness" in business—a subject which makes attractive political slogans possible. The recent Supreme Court decision against Du Pont is an outstanding example of an opening gun in what may prove to be the beginning of an extended campaign along this line.

Horizontal and Vertical

The ultimate effects of the Du Pont case, certainly the most momentous decision in many years, still cannot be fully evaluated. There has been nothing of comparative importance since 1911 when the Standard Oil Co. of New Jersey was ordered dissolved. The significance of the decision is that it questions the whole matter of "vertical" acquisitions of stock in other companies which are in a business unlike that of the firm that does the buying.

Heretofore, antitrust actions have been chiefly to restrain the "horizontal" acquisitions of firms that are in direct competition with the buyer. Business men and their lawyers have been cognizant of this situation for many years and no major chemical firm, for example, would be rash enough to consider taking over a major competitor, knowing that they would run into trouble. But now, under this latest decision, every company that has acquired stock in another more or less unrelated firm since 1914 is exposed to this new interpretation of the law and such holdings may be called into question.

It seems certain that corporation lawyers, in advising their clients on the feasibility of "vertical" mergers or acquisitions in the future, will be even more cautious and conservative in their advice than they have been in the past. The decision may therefore slow down the trend that has appeared in the chemical industry to diversify in products closer to the consumer by acquiring customer firms.

Oil on the Spot

Still another facet of the situation is the increasing indication that a main target of both Democratic and Republican forces over coming months will be the far-flung oil industry. It is the belief that oil firms will be attacked on the ground of bigness, on depletion allowances, on taxes, and on their pipe lines, with a possible effort to break up the pipe lines. Many legal authorities feel that Du Pont was really attacked on the ground of bigness, since the Chicago courts decided against the Attorney General on the facts in the case. If bigness becomes the real issue, Standard Oil of N. J., which is larger in assets than Du Pont (even including its General Motors holdings at their $2,500,000,000 market value) might be a vulnerable target.

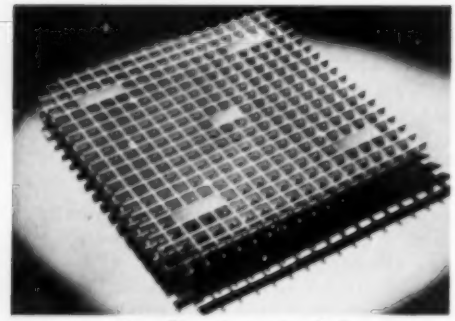
The depletion allowances of the oil companies have of course financed the high costs of exploration, development, the finding of new fields, and the drilling of new wells. Some chemical men, however, point out that funds from these sources have made it easier for oil firms to go further into the petrochemical business, especially into ammonia. Even though new ammonia plants may not be needed currently, they provide a means of using surplus funds, with the knowledge that under inflation the cost of such plants will probably go up every year.

Labor's Demands

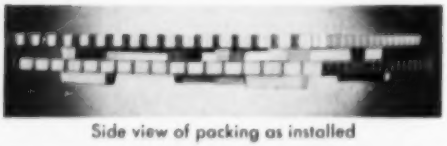
Another direction from which business may be attacked is through labor unions and labor leaders. This will not necessarily be simply on questions of more money and more benefits, although these demands are likely to continue. There have already been rumblings from Reuther of the motors unions on the subject of the four-day week. Labor people also may attack industry on the ground of "bigness." One reason for doing this would be as a means of combatting the public's growing acceptance of the idea that the spiral of wage advances, touching off price advances, is directly responsible for inflation. A lesser but still cogent reason would be to draw a smokescreen over revelations of malfeasance in labor unions which could result in legislation aimed at curbing labor "bigness."

announcing

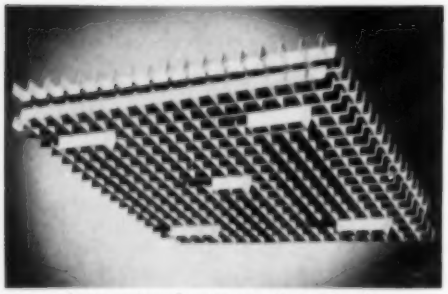
FLUOR'S NEW poly-GRID



Overall top view as installed



Side view of packing as installed



Bottom view showing spacing supports

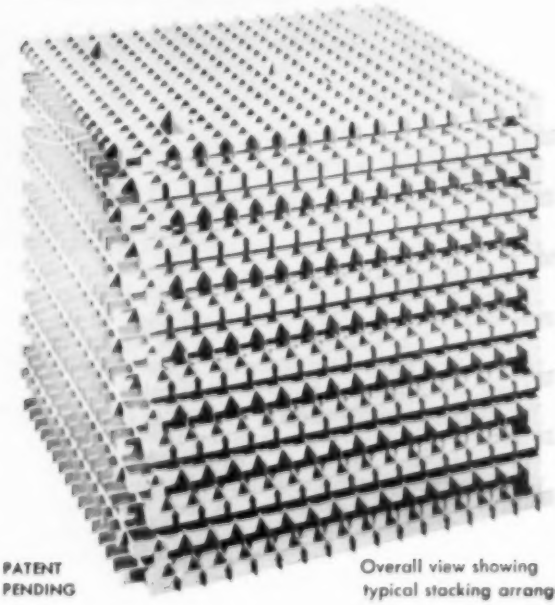
MORE COOLING IN YOUR EXISTING TOWER

To increase the throughput of your existing counterflow induced draft cooling tower, Fluor Products Company now offers "Poly-Grid" packing.

This revolutionary packing provides greater cooling surface — greater overall heat transfer; yet construction is open, and pressure drop low.

"Poly-Grid" is available in high impact polystyrene or linear polyethylene to meet all water conditions.

Fluor "Poly-Grid" packing allows you to cool more water under existing operating conditions, or to realize extra cooling of present throughput — all at minimum capital expenditure.



PATENT PENDING

Overall view showing typical stacking arrangement

Contact your nearest Fluor Representative for details.

POLY-GRID can be easily installed in any counterflow induced draft cooling tower—regardless of make or model!

Call him today!

FLUOR PRODUCTS COMPANY

A DIVISION OF THE FLUOR CORPORATION, LTD.

fp GENERAL OFFICES • WHITTIER, CALIFORNIA

CEP

opinion and comment

I.G.Y.

The International Geophysical Year is now under way, as of July first. Symbolic of scientific cooperation on a basis which transcends political alignments, the I.G.Y. exists for the purpose of making observations in parts of the world (particularly the Antarctic) which are normally neglected, and of making simultaneous observations of events on the earth and in its atmosphere that have a common origin in the sun.

That the sun will be of interest to future generations of chemical engineers there seems no doubt—if one heeds the energy picture described by Spaght, and also by Furnas, in this issue.* From unlocking the secrets of photosynthesis as demonstrated by the everywhere-present (except on the drugstore counter) chlorophyll, to the direct capture, storage, and thus harnessing of the thermal energy of the sun, chemical engineers are now interested in, and will someday be engaged in large teams to study, the wider utilization of sunlight. Doubtless many of the I.G.Y. observations related to the sun's effect on the earth will ultimately contribute in one way or another to the job of making and fitting that harness.

One of the most dramatic events of the I.G.Y. will be the launching of the earth satellites. Here the chemical engineer has been directly involved as a contributor. As will be revealed in some detail in papers to be presented before the Baltimore A.I.Ch.E. meeting in September, Project Vanguard (as the satellite construction and launching program is termed) has depended upon the cooperation of several chemical company groups to provide the propellants for the three stages of rockets which it is hoped will get the satellite sphere into orbit.

Lest one believe that I.G.Y. is the first of such international scientific cooperatives, it should be mentioned that there were two previous ones. I.G.Y. is really a repetition and extension of the International Polar Year of 1932. This in turn, was a repetition and extension of the first Polar Year of 1882.

INSTITUTE'S 49TH

Only days ago, the Institute passed its forty-ninth birthday. No cards or presents were received. No cake with even a single candle was sliced and consumed. Clearly, forty-ninth anniversaries aren't in their own right important, recognized, or even remembered. The trouble is that the forty-ninth suffers from being so close to the fiftieth, the one chemical engineers around the world are waiting for—yes, even working for. Our fiftieth year promises to be a great one, packed (around mid-year) with drama, notables, and perhaps above all, a recapitulation of our status in the scheme of things that may help to establish a clearer over-all picture of what chemical engineering has helped accomplish, and what the job is ahead. Soon, *CEP* will be running articles and information which will keep the reader informed as to basic plans and their development into a full-fledged Jubilee.

—J.B.M.

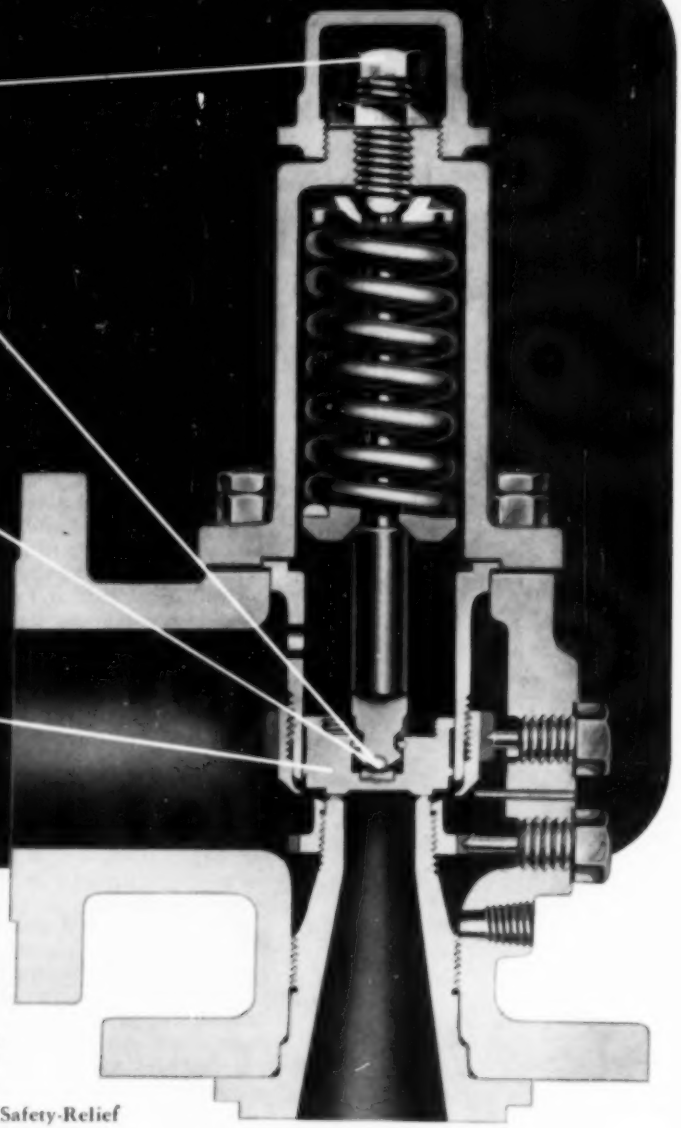
* Noted & Quoted, page 30.

ADJUSTING BOLT is pressure tight — fluid cannot escape if cap is removed while valve is in service.

HARDENED BEARINGS are used on spindle and disc to insure retention of popping point.

DIRECT SPRING LOADING of disc at lowest possible bearing point to insure uniform seating.

LONG LASTING solid disc construction — can be remachined many times before replacement is necessary.



CROSBY NOZZLE TYPE RELIEF VALVE

Every feature of Crosby Nozzle Type Safety-Relief Valves is engineered for high performance and long service. These valves are furnished in D, E, F, G, H, J, K, L, M, N, P, Q, S, and T orifice sizes, and with inlet sizes from 1" to 8". Cast steel valves are furnished for temperature to 800°F, alloy steel valves for temperature to 1400°F. All Style JO valves have forged stainless steel FULL NOZZLE construction.

Write for Bulletin describing Crosby Relief Valves — or ask for our quote on your valve requirements.

CROSBY VALVE & GAGE COMPANY
43 Kendrick Street, Wrentham, Mass.



ALSO MANUFACTURERS OF A COMPLETE LINE OF INDICATING PRESSURE GAGES

Crosby
KEEPS PRESSURE ON THE SAFE SIDE

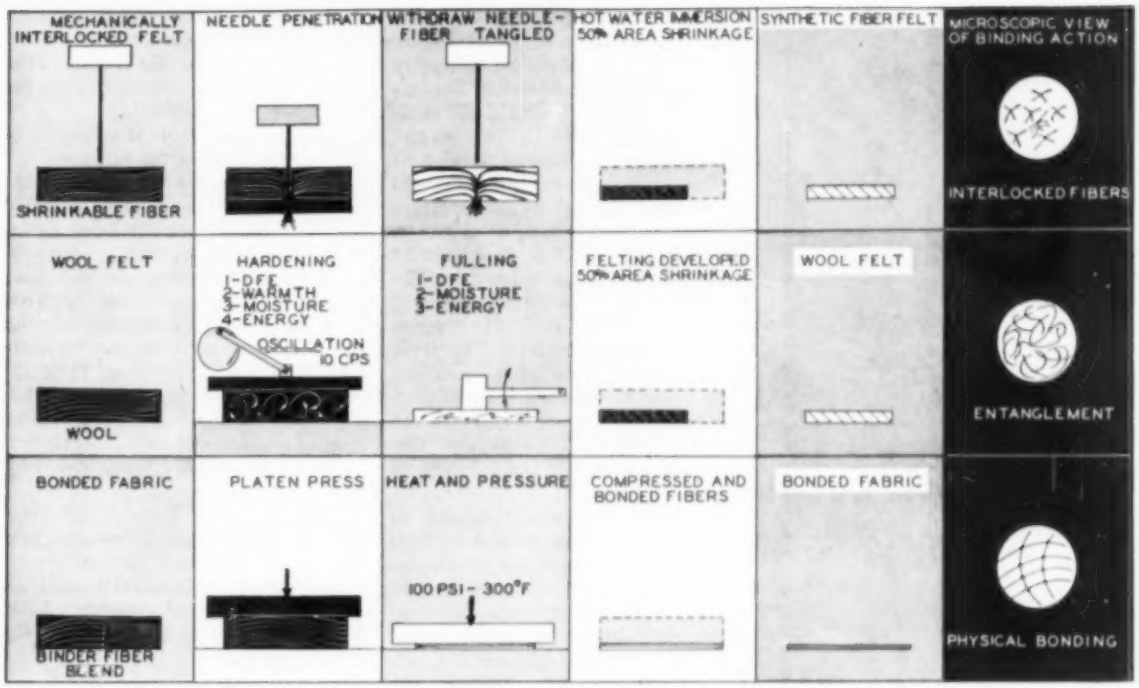


Fig. 1. Nonwoven fabric manufacturing processes.

NONWOVEN FILTER MEDIA

Arthur C. Wrotnowski | American Felt Company, Glenville, Connecticut

Nonwoven fabrics, by definition itself, includes fabrics that lack woven threads. Under this category there is a relatively new process of mechanically interlocking fibers reported by Lauderbach (*10*), and by the American Society of Testing Materials on the traditional wool felt (*2*) and on the twenty-year old family of bonded fabrics (*3*). The filtration characteristics of each type will be discussed separately with special emphasis on their suitability for chemical processing for which the new synthetic fibers are so well suited.

With regard to the three types of nonwoven fabrics, it will be shown that

1. *Mechanically Interlocked Fiber* products are still too new for general industrial acceptance, but their eventual acceptance will be based on high strength, low-pressure drop, uniform fiber distribution, ease of solids removal, and versatile fiber selection.

2. *Wool Felts* have physical and chemical properties that set them apart from synthetic fibers. High- and low-temperature resilience, complete stability in petroleum and solvents, and third dimensional application of edgewise filters are available in this economical material.

3. *Bonded Fabrics* of synthetic fibers have high strength, low porosity, chemical stability, gasket action, nonblinding and nonbleeding properties.

Today the field of bonded fabrics is growing rapidly and is now approaching an annual production of 100 million pounds. However, the materials are mainly cellulosic and are intended for uses other than industrial filtration. It is the intent of this paper to report progress of synthetic fiber-bonded fabrics, the materials of manufacture and suitability as filter media.

Figure 1 schematically portrays the manufacturing processes of the three materials under consideration. The starting point for all materials is fibers in batt form as prepared by a textile carding machine. A follow-through of the steps of the mechanically interlocked felt, reported by Lauderbach (*10*) shows step one as a barbed needle poised over the batt, the needle penetrating the batt-carrying fibers in the depthwise direction. In actual production there can be as many as 1,000 needle penetrations/sq.in. As the needle withdraws, the fibers remain in their depthwise position. When shrinkable Dacron is used, immersion in hot water causes the individual fiber to shrink 50% of its length. Fiber-shrinking force is strong and in the felt, fiber friction permits this force to strongly bind the mechanically interlocked felt in three dimensions. The final product in this case is strong, chemically and physically stable Dacron felt.

Wool fiber is a product of nature with a unique property called directional friction effect (DFE). This means that wool fibers have a higher coefficient of friction in one direction. This is a result of microscopic scales on the fiber surface which look like and act like fish scales. For example—two wool fiber scales in opposite direction, placed adjacent, with gentle movement, will move in opposite directions. It has been found that certain environmental conditions accelerate this fiber movement which is

Tables 1-12, supplementary data, are on file (Document 5264) with the American Documentation Institute Auxiliary Publications Project. Material is obtainable by remitting to Chief, Photoduplication Service, Library of Congress, Washington 25, D. C., $1.75 for a microfilm or $2.50 for photoprint.

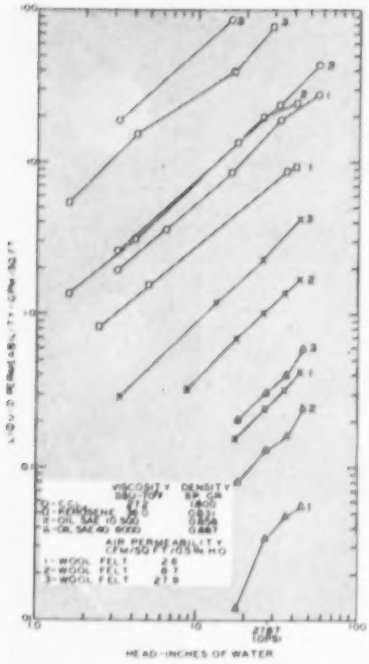


Fig. 3. Liquid permeability vs. head.

Table A.

Flow rate gal./hr.	Quantity of particles	Particle leakage μ
1	None visible	Less than 1
6	Few	4
25	Great many but very uniform in size	10

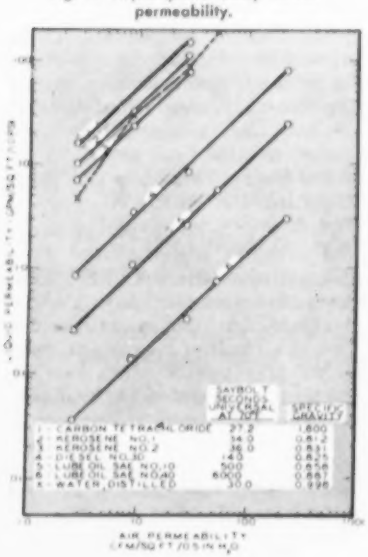


Fig. 4. Liquid permeability vs. air permeability.

also called "felting." Step 2 of the wool-felt manufacturing steps (Figure 1), indicates the conditions necessary to develop DFE in wool-felt "hardening," are moisture, warmth, and oscillating energy. After a "hardening" step in which oscillatory motion is applied to the wool fiber mass, the felt is strong enough to absorb larger amounts of energy thus, as shown in step 3, it is "fulled" or compacted by striking it with a heavy hammer. The increased force induces additional fiber movement and this action strongly binds the fabric in three dimensions. Felting alone can develop a fabric with a density of 70% sp. gr. Also the wool-fiber content can be reduced to 20% and that amount of wool fiber can felt 80% of a nonfelting fiber.

Bonded fabrics are composed of fibers that have been bonded by high pressure and temperature which activate an adhesive. In practice the degree of fiber compression achieved during manufacture is retained in the completed bonded fabric. The adhesive can be an external one such as rubber, latex, synthetic resin (thermoplastic or thermoset), latex, or powders of (thermoplastic or thermoset) synthetic resin. Fiber bonding can be obtained also by binder fibers or in the case of synthetic fibers a cohesive bond is possible by chemically or thermally fusing the fiber to itself. In the case of chemical filtration the binder determines bonded fabric chemical stability. For purposes of this work two binder fibers Vinyon HH and Fiber B * will be considered.

* Carbide & Carbon's experimental high-temperature polyethylene fiber.

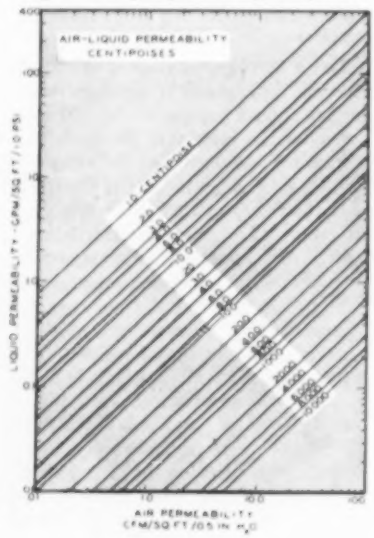


Fig. 5. Air-liquid permeability, centipoises.

In Figure 1 the manufacture of bonded fabrics involves simply the hot platen pressing of the binder fiber blend. This one operation densifies and bonds the material.

Figure 2 gives typical examples of various filter media for end uses.

The physical properties of nine nonwoven filter media are given in Table 1, all of these materials being fabricated fiber by fiber, that is, when cut in any direction they do not have threads that unravel. The synthetic fiber materials are manufactured with the "heat set" property and therefore have complete stability in three dimensions. As a result their permeability value is constant. They are all tough materials and used properly will serve as industrial fabrics with long life.

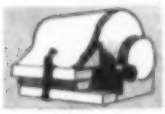
Examination of Table 2 will show that the mechanically interlocked felts show great promise in the field requiring chemical and thermal stability. Based on chemical stability dollar value, experimental Fiber B offers the most promise.

Liquid Permeability Values for Various Viscosities and Pressures

There is an understandable tendency to select filter cloths which have maximum allowable permeability, the inference being that the filter cloth will remain relatively open so as not to cause reduced flow rate. However, in a decision of this kind other factors that can be obtained from a less permeable filter cloth are sacrificed. The purpose of the accompanying illustrations is to assist and encourage the selection of the tightest filter material, which by comparison will give maximum particle retention, cake release, physical strength and life, yet be permeable enough so as not to restrict flow rate.

Figures 5 and 6 give the liquid flow rate of clean filter media whose air-permeability value falls within 0.1 to 100 cfm/sq.ft./0.5 in. HO_2 for nonaqueous liquids whose absolute viscosity ranges between 1.0 to 10,000 centipoises when the hydraulic pressure varies between 1 to 1000 in. of water.

It is necessary to limit these data to nonaqueous liquids because it has been observed that distilled water has a plugging effect. For example, while passing distilled water through a filter medium at a constant head, flow rate gradually decreases; an example is plotted in Figure 4. Plugging action was found also to occur with freshly boiled distilled water, distilled water to which a wetting agent has been added in one case and 20% alcohol in another, as well as in a 5% Na_2SO_3 solution in which dissolved



FILTRATION

Table 7.—Bleeding. (1% water slurry, Ry ash SN-183*)

Description	Weight oz./sq.yd.	Thickness in.	Density % Sp.Gr.	Air permeability cfm/sq.ft./ 0.5" H_2O	Initial filtrate—no cake formation: Ocular micrometer—900X: Number of particles	Largest particle microns
Mechanically interlocked felt						
Orlon 3.0 dpf—#61	18	.08	30	18	few	7
Dacron 3.0 dpf—#61	18	.08	30	18	great many	13
Wool felt						
Silk wool—#1405	23	.86	30	2	none	0
Cotton-wool—#3060	12	.08	20	30	trace	5
Wool—#51002	19	.08	33	20	few	7
Wool—#51018	66	⅛	18	14.	few	10
Coarse hair—#70198	9	.08	13	220.	great many	43
Bonded fabric						
Dacron 3.0 dpf	3	.009	48	20	great many	11
Dacron 3.0 dpf	10.5	.020	70	2	trace	5
Dacron 3.0 dpf	21	.040	70	0.7	trace	3
Nylon 1.5 dpf	10.5	.030	47	2	trace	3
Nylon 15.0 dpf	10.5	.050	28	50	great many	20
Dynel 3.0 dpf	3	.009	48	20	many	8
Dynel 3.0 dpf	10.5	.030	70	1	none	0

* Particle size analysis of Ry ash SN-183 (%):

0.0— 7.5 microns	38.2
7.5— 20 microns	27.0
20— 60 microns	24.6
60—200 microns	10.2
	100.0

Table 2.—Chemical and Thermal Properties

Description	Maximum concentration—% † H_2SO_4	NaOH	Acetone	Petroleum	Maximum recommended operating temperature
Mechanically interlocked felt					
Orlon	40 at 70° F.	40 at 70° F.	100	100	230
Dacron	70 at 70° F.	40 at 70° F.	100	100	300
Fiber "B" *	50	100	100	100	340
Teflon *	100	100	100	100	400
Bronze *	0	0	100	100	600
Stainless steel *	0	0	100	100	600
Wool felt					
Wool	0	0	100	100	220
Bonded fabric					
Dacron "B"	70 at 70° F.	40 at 70° F.	100	100	240
Dynel—Vinyon	40	40	0	100	180
Nylon "B"	0	40	100	100	240

* Developmental felts by American Felt Company.
† For Chemical Stability at maximum temperature, except where indicated.

oxygen was chemically removed. Based on the work done here, and other work with ion exchange resins where it has been observed that the dissolved gases are collected in ion exchange resin beds and reduce flow rate, it is assumed that dissolved oxygen and nitrogen are probably collected on the filter medium which restricts flow rate. This plugging action occurs on cellulose, on wool, and even on the hydrophobic synthetic fibers which have complete dimensional stability in water.

Contrary to the plugging effect noted with aqueous solutions, all the various nonaqueous liquids tested demonstrated reproducible straight-line logarithmic relationships. Regardless of the noncorrelation of aqueous liquids, the presented data should prove helpful in most filtration problems.

The aim of this work is the correlation of liquid permeability expressed as g.p.m./sq.ft./1.0 lb./sq.in. and air permeability expressed as c.f.m./sq. ft./0.5 in. H_2O. Basic data for the permeability study is given in Table 3 and is plotted on Figure 3, actually seven liquids and five wool felts establishing the relationship between liquid permeability, viscosity, hydraulic head, and air permeability. Only four liquids and three wool felts were plotted in order to prevent crowding of Figure 3.

Results plotted in Figure 3 show that the relationship of liquid permeability and hydraulic head plotted on log-log graph paper is a straight line with a slope of 45 degrees and this is true for all liquid viscosities and felt permeabilities tested.

The liquid permeability values obtained in Figure 3 were plotted against the air-permeability values as shown in Figure 4. Again with a plot on log-log paper it is interesting to note that the relationship of air and liquid permeability proved to be a straight line with a slope of 45 degrees.

To complete the viscosity-permeability correlation

- The Saybolt Seconds Universal units (S.S.U.) were converted to centipoises (Table 4).
- The actual distances between the 45 degree viscosity lines of Figure 4 were separately plotted against the centipoise value of the individual lines.
- From this separate plot the actual distance for even numbered centipoise values was obtained.
- Data of Figure 4 were replotted with even-numbered centipoise values and is shown in Figure 5.

It is interesting to note that the centipoise values obtained on the completed graph have a logarithmic frequency.

The test results plotted in Figure 3 show that flow rate and hydraulic head plotted on log-log graph paper have a slope of 45 degrees and this is true for all felt permeabilities and liquid viscosities tested. This graphic relationship is also true for woven cotton and wool felt when tested for air permeability within a range 0.08-9.0 in. water pressure drop (*7*), as well as for Dynel bonded fabric and water (Figure 13) 10-80 lb./sq.in. pressure drop.

By a recapitulation of the data of Figure 3, the published data by Drinker and Hatch (*7*) and the pressure drop data of Figure 13 show that fibrous filter media (woven or nonwoven with fiber cross section circular or irregular) through which permeates air, solvents, water, or high viscosity liquids the pressure drop-permeability graphic relationship described above, applies.

For the convenience of predicting flow rates other than those at a head of 1.0 lb./sq.in. as obtained from Figure 5, Figure 6 has 45-degree plots on log-log graph paper.

By the use of Figure 5 the liquid flow rate of clean filter material of

Fig. 2. Typical examples of filter media for end uses.

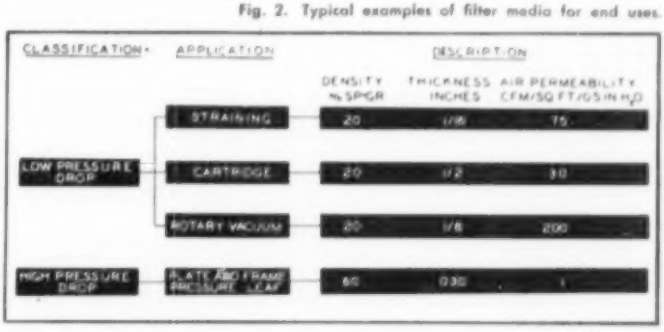




Fig. 6. Flow rate vs. hydraulic head.

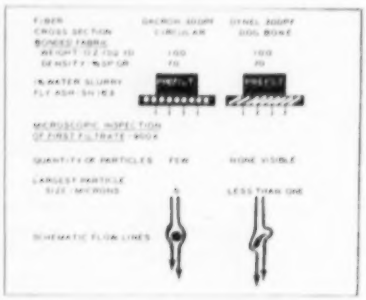


Fig. 7. Comparison of axial- and transverse-fiber flow.

Table 1.—Physical Properties

Description	Weight, oz./sq.yd.	Thickness, in.	Density, % Sp.Gr.	Porosity, % voids	Bursting strength, lbs./2 in. width	Tensile strength, lb./sq.in.	Mullens bursting strength, lb./sq.in.	Air permeability, cfm/sq.ft./10.5 in. H_2O	Diesel oil 3 D Permeability, cfm/sq.ft./1.0 lb.sq.in.†	Particle retention, microns*	Comments
Mechanically interlocked felt											
Orlon 3.0 dpf No. 61	18	0.08	30	74	170	1,060	500	18	6	7	Low pressure drop, high solids capacity.
Dacron 3.0 dpf No. 61	18	0.08	30	78	250	1,560	550	18	6	12	Stable to mechanical action, backwash will unload filter cake and clean cloth.
Wool felt											
SAE F-1	124	⅛	33	75	500	500	over 500	2.6	0.9	10	Hydraulic line plug filter.
SAE F-10	68	⅛	18	86	200	200	over 500	14	4.8	7	Edgewise filtration.
Cotton-Wool	12	0.08	20	86	70	440	225	50	18	5	Fine particle retention at low pressure drop.
Hair	8	0.08	13	90	20	125	90	220	79	45	Coarse strainer and vacuum filter media.
Bonded fabric											
Dacron 3.0 dpf "B" ‡	10.5	0.02	70	40	200	5,000	350	2	0.7	5	Corrosive chemical Plate Frame. Filter Cloths.
Dynal 3.0 dpf Vinyon	10.5	0.02	70	44	85	2,100	230	1	0.35	less than 1	
Nylon 1.5 dpf "B" ‡	10.5	0.03	47	55	200	3,950	390	2	0.7	2	

* Largest particle visible with filar micrometer-900X, initial filtrate, no filter cake formation. 1% Water slurry of fly ash SN-183, particle size analysis given in Table 7.

† 140 Seconds Saybolt Universal at 70° F. specific gravity 0.825. Absolute viscosity 29.8 centipoises.

‡ Fiber "B" is an experimental polyethylene staple fiber under development by Carbide & Carbon Co.

known air permeability can be determined. The flow rate obtained from this figure, regardless of viscosity, can be entered then in Figure 6 to obtain flow-rate values at various hydraulic head values.

With regard to limitations of using and interpreting these data in commercial applications, it should be remembered that in actual filtration suspended solids in raw liquor quickly clog filters and assume control of over-all permeability values.

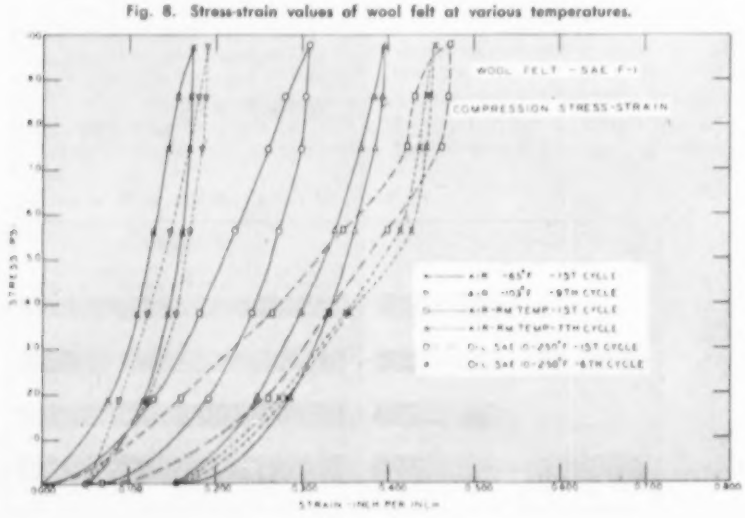
Filtration Characteristics of Wool Felt

A low-density wool felt has a higher capacity for gelatinous particles before plugging than other filter types of filter media.

Proper design methods will give greater performance values. For example, an edgewise filter unit which has an effective filter area 55 sq.in., demonstrated the following particle leakage values when filtering domestic fuel oil No. 2 as shown in Table A. Other particle leakage values for wool felt are given in Table 7, page 315.

The edgewise principle of filtration is easily and effectively applied when wool felt is used. Figure 7 graphically demonstrates the advantage of axial-fiber flow over that of transverse-fiber flow. Table 5 gives the test results and method used to evaluate direction of flow. It is believed that filtered solids penetrate deeper into the filter bed-fibrous mass because of fiber alignment. As a result more than double the solids capacity at a lower pressure drop is achieved. Application of this principle offers increased economical performance for new filter equipment design.

Fig. 8. Stress-strain values of wool felt at various temperatures.



Of interest in the selection of filter media for design, the compression properties of wool felt (Table 6 and Figure 8) present stress-strain values of wool felt at room temperature and at two extreme temperatures. The test method consists of cyclically compressing the test sample until it returns to its starting thickness, which establishes equilibrium conditions. A study made at room temperature, took seven cycles to reach equilibrium condition and it took a 15% set based on the original thickness. While at 250° F. in SAE No. 10 oil, it took only six cycles and it should be noted that again it took only a 15% set. This desirable thermal property is a result of its nonthermoplastic nature and freedom from a

"second order transition temperature." In the case of the —65 to —103° F. test, complete and functional resilience is noted, freedom from embrittlement and freedom from subsequent failure are indicated.

Filtration Characteristics of Mechanically Interlocked Felt

The great potential of mechanically interlocked felts in chemical processing is the use of the chemical stability of synthetic fibers. Table 2 indicates the variety of chemical-processing jobs of which these products are capable.

At the moment these materials are relatively new, but successful pilot plant runs have been made on plate-and-frame filters and rotary vacuum filters with excellent results.

Filtration Characteristics of Bonded Fabrics

Of great importance is the cross-sectional shape of fibers which can have a major effect on particle leakage. Ribbon- or dog-bone-shaped fibers display outstanding particle retention whereas fibers with a circular cross are subject to particle leakage. Bonded fabrics offer a practical method of orienting and fixing fibers in place to obtain highly effective filter media.

Bonded fabrics have high density and low porosity, high tensile strength, high wear abrasion, long life as an industrial fabric, a fiber-free surface, product homogeneity, and stability. It will be shown that the high tensile strengths available in these products place them in the industrial fabric category, which permits the use of other numerous favorable physical properties, details of which follow.

BLEEDING

The term "bleeding" commonly used to describe particle leakage is the key filtration requirement in recovering solids of fine particle size. It has been known for some time that cotton cloth produces a filtrate of greater clarity than one of wool (*6*). This can be explained by

1. *Fiber diameter approximately 10μ for cotton against 20μ for wool, and*
2. *Fiber cross section flat ribbon for cotton against circular for wool.*

With a laboratory method, a difference in particle-size retention value has been observed also in synthetic fibers. Test results are given in Table 7 and two examples are pictured in Figure 9.

Procedure for the test method follows:

1. Insert test sample in modified manometer.
2. Pump 1% fly ash water slurry into rapidity tester.
3. Collect initial filtrate.
4. Pass the initial filtrate through a Buchner filter, No. 10 Whatman paper.
5. Dry the filter paper.
6. Measure the largest particle present by means of an ocular micrometer at 900 diameters.
7. Report the particle size in microns as the largest size particle to pass the test filter media.

It will be noted that in the above procedure, particle leakage occurs before a filter cake can form. The test method therefore reflects the particle retention capacity of the filter medium itself.

Test results of bonded fabrics as well as mechanically interlocked felts and wool felts are reported in Table 7.

The cross section of the fibers tested is shown in Table B.

Test Results

In Table 7 the mechanically interlocked Orlon felt Test No. 1 which has the same fiber denier, felt weight, and density as Dacron felt, Test No. 2, has a significantly better particle-retention value. This is attributed to fiber cross section.

Direct comparisons are not present in the wool-felt section, but Test No. 4 cotton-wool No. 3060 has outstanding particle-retention property in view of its low density. Test No. 4 coarse hair No. 70158 indicates particle-leakage properties suitable for straining paint and pigments.

In the bonded fabric section there are several direct comparisons of circular vs. dog-bone fiber cross section. For example,

1. Test No. 8, Dacron 3-oz./sq. yd. vs. Test No. 13, Dynel 3-oz./sq. yd. Although both samples are lightweight, the comparison demonstrates the effect of fiber cross section.

2. Test No. 9 Dacron 3.0 denier/filament; Test No. 11 nylon 1.5 denier/filament, and Test No. 14 Dynel 3.0 denier/filament, all have the same weight yet the dog-bone fiber, Dynel, is the best.

Finally in a 21-oz./sq. yd. Dacron, Test No. 10, was not as good as Test No. 14, Dynel, at 10.5 oz./sq yd.

Particle-leakage problems encountered in industrial filtration of dyestuff confirm the laboratory tests above. Fiber selection with reference to cross section is therefore an important consideration where "bleeding" is undesirable.

Permeability

EFFECT OF FIBER CROSS SECTION

A detailed permeability comparison of Dynel 3.0 denier/filament and Dacron 3.0 denier/filament (Table 8 and Figure 10) showed that the "circular" cross section fiber, Dacron, is two to four times more permeable (fabric weight and density constant) than "elongated dog-bone" (*9*) fiber,



FILTRATION

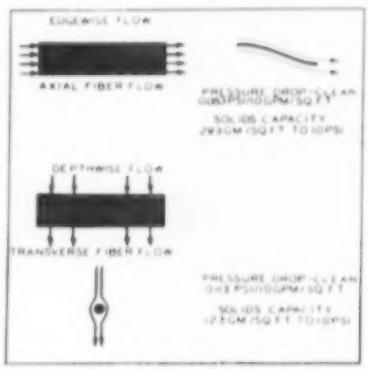


Fig. 9. Bleeding as a function of fiber cross section.

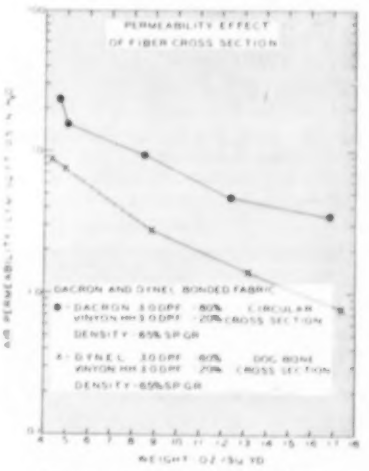


Fig. 10. Permeability effect of fiber cross section.

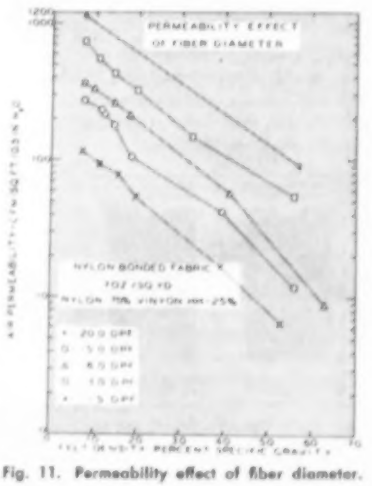


Fig. 11. Permeability effect of fiber diameter.

Table B.

Circular	Ribbon or Dog-bone
Dacron	Orlon
Wool	Tussah Silk
Hair	Cotton
Nylon	Dynel

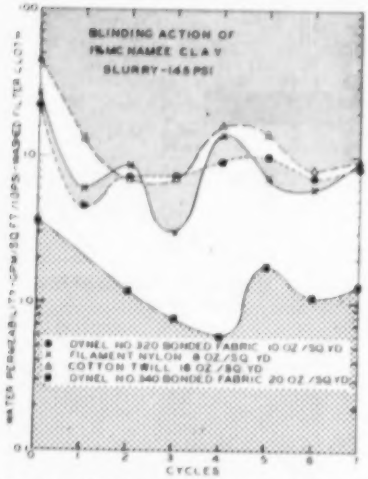


Fig. 12. Blinding action of 1% McNamee clay slurry—145 lb./sq.in.

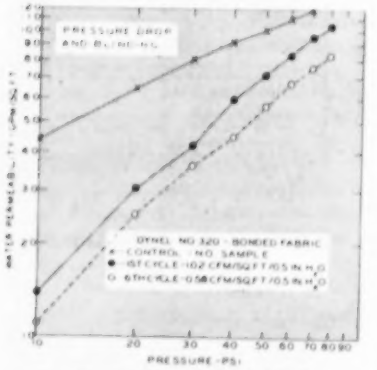


Fig. 13. Pressure drop and blinding.

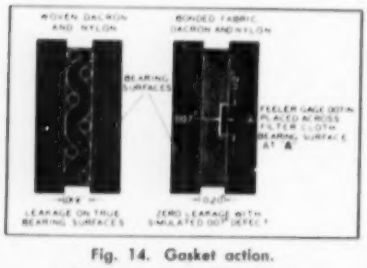


Fig. 14. Gasket action.
Plate and frame filter press.
City water—RM. temperature—50 lb./sq.in.

Dynel. The smaller air permeability value of Dynel is consistent with the data on bleeding (Table 7). A circular cross-sectional fiber offers less resistance to fluid and particle flow, the more irregular the fiber cross section the more the resistance and, in this case, the more efficient in particle retention.

EFFECT OF FIBER DIAMETER

To demonstrate that fiber diameter and felt density control permeability, five deniers of nylon were prepared as bonded fabrics for comparison. Results are given in Table 9 and plotted on Figure 11. Bleeding (Table 7) will show the particle retention of two deniers of nylon fiber where 15.0 denier filament fiber exhibits greater particle leakage than 1.5 denier/filament. A similar gradation would be expected here with the various diameter fibers.

A practical use of the test materials under consideration would be as a series of strainers with extremely fine differences of particle separation.

BLINDING ACTION

Filter cloth blinding refers to permanent plugging or clogging of filter media as caused by solids which permanently lodge in the fabric. This action is obviously undesirable because eventually the filter cloth loses all permeability.

In order to measure the blinding action of bonded fabrics in comparison with standard woven filter cloths, four test samples were given a series of plate-and-frame filtration cycles collecting McNamee clay. The test results which show that bonded fabrics and woven goods have parallel blinding action values, are given in Table 10 and Figure 12.

The test was performed on a pilot plant filter press. All samples were run simultaneously at room temperatures by pumping a 1% slurry through the samples to a pressure of 145 lb./sq. in. and maintained for 5 min. The samples were removed from the filter press, the cake was removed and flushed off with a hose. After drying, the samples were tested for air permeability, which was converted to water permeability by means of the data presented in Figure 5. These values are given in Table 10. The procedure was repeated through seven cycles and the results are graphed in Figure 12.

Variations obtained in the washed-and-dried filter cloths are probably due to incomplete removal of clay solids since only superficial cleaning was done to simulate field conditions. However, the results show that recycled filter cloths tend to level off in permeability at approximately one third of the clean cloth value. Test sample No. 4, an extremely tight Dynel bonded fabric, roughly paralleled the values of the more open and conventional permeabilities. This indicates that a tight-bonded fabric does not tend to "blind" and that it and the other samples are suitable for use as a filter medium. Sample No. 4 demonstrates, as previously mentioned, that the selection of filter-media permeability can be much tighter than is generally used without restricting flow rate. For example, in doing this work the permeability of the McNamee filter cake was found to be 0.76 gal./(min.)(sq. ft.) at 145 lb./sq. in., which is equivalent to 0.02 gal./(min.)(sq. ft.) at 1.0 lb./sq.in. The lowest permeability values of sample No. 4 occurred on cycle 0 or 0.6 gal./(min.)(sq. ft.) at 1.0 lb./sq. in. which is thirty times more permeable than the filter cake.

Another aspect of filter-cloth blinding is that prolonged filtration of low-solids liquor such as city water tends to blind filter cloths. An example of this is given (Pressure Drop and Blinding Section).

Flow-rate pressure-drop information is basic information necessary for filter-cloth design and application. Tests performed show that the relationship is a straight line logarithmic function.

PRESSURE DROP FOR BLINDING

In order to establish pressure drop and clean water flow rates of typical bonded fabric, a test series was performed on a plate-and-frame filter press.

The filter press was used as flow-rate test equipment and, as will be shown, it had limited value because high flow rates were obtained. Clean water was prepared for the test by recirculating city water through a separate filter cloth. After a half-hour of filtration the test samples (effective filtration area 36.0 sq. in.) were placed in the filter press and a calibrated rotameter was placed in the recirculation system. Flow rates were recorded at given amounts of increased pressure, results given in Table 11 and Figure 13. Six cycles were performed one after the other.

As shown clean-water-flow reproducibility was not obtained. However, the results were consistent because the value of cycles 2, 3, 4, and 5 fall within those of cycle 1 and 6. Nor did the viscosity flow-rate values correlate with the results obtained on the modified manometer and presented in Figure 5. As previously explained, aqueous-nonaqueous correlation was not obtained on the modified manometer.

However, significant values were obtained when plotted on log-log graph

paper. In this case the graphic relationship of cycles 1 and 6 was essentially straight with a slope of 45 degrees which is characteristic of streamline or laminar flow. The control value with no sample when plotted had a slope of 26 degrees which indicate turbulent flow and which was due to the filter press restriction with respect to the flow rate.

At 80 lb./sq. in. the control and test values approach each other. The fact that the test sample had a different slope indicates the validity pressure-drop test results.

Another factor in this test was the fact that although thoroughly filtered water was used, the air-permeability values of the test sample before and after the test indicated considerable plugging, which points out that prolonged filtration on low-solids content raw liquor tends to blind filter cloths.

In view of the consistent values obtained, it is believed that cycles 1 and 6 represent clean-water flow rate of filter media with an air permeability of 1.02 and 0.58 c.f.m./sq.ft./0.5 in. H_2O respectively. However, viscosity correlation betwen aqueous and non-aqueous liquids is incomplete.

GASKET ACTION

The edge leakage of filter cloths in plate-and-frame filtration must be a minimum value for a filter press to function properly. In most cases when the filter cake forms, edge leakage is reduced to a practical level. This is especially true in the case of cotton cloths where fiber swelling and fiber compressibility develop in water. However, synthetic fibers, which are hydrophobic in nature, do not swell or change their compressive properties in water. In the form of woven cloth they are characteristically subject to excessive edge leakage.

A test method employed was used to compare directly the gasket action of identical synthetic fibers in the form of woven cloth and bonded fabrics. The pilot plant filter press with city water only, again was used as test equipment. Procedure follows:

1. A single test cloth was placed in the filter press.
2. Filter press discharge valve was closed to develop back pressure.
3. Machinist-feeder gauge in various thicknesses as indicated in Table 12 was placed across the filter-cloth bearing surface.
4. If leakage, determined by visual observation, was not obtained the pressure was raised to 50 lb./sq. in.

Test results of Table 12 show persistent leakage on true bearing surfaces for woven nylon and Dacron. This is explained by the tough cross-sectional strength which keeps the weave channels open for fluid flow (see Figure 14).

Results on the bonded fabrics show complete gasket action up to a simulated defect .006 in. for both 10 and 20 oz./sq. yd. materials. However, at .008 in. the lighter weight material remained sealed while the heavier material would not seal. Further work on this test method could determine the exact point of incomplete gasketing, also whether feeler gauges placed on either side of a sample could show, for example, a given sealing capacity on each surface of a bonded fabric.

The test clearly measures the difference in gasketing action between woven and bonded materials. Other means of controlling edge leakage, such as edge dipping with wax, plastic, or other suitable materials, and in some cases elevated temperature will control leakage. However, a filter cloth such as cotton cloth or bonded fabric are inherently gasket materials.

ADDITIONAL PROPERTIES

There are functional advantages of bonded synthetic fibers over woven synthetic fibers, in addition to the points covered previously, which indicate suitability for corrosive chemical filtration. The additional properties of interest are as follows:

1. Dimensional stability is outstanding. There is 0.0% area shrinkage and no perceptible thickness change in chemicals or boiling water. Perfect realignment is assured eliminating bias-stretch problems and heat-setting expenses.
2. Nonravel properties eliminate the need for heat seal cutting or whipping of selvages and drainage port holes.
3. Cake-release properties and filter-cloth life are favorable.
4. Ease of installation.
5. Economic advantage is realized on initial cost, performance, and life.



Fig. 15. A vacuum-molded drainage member edge-fused between two bonded fabric filter media. A discharge pipe is later attached at the indicated nozzle location.

The above points compared to woven cloth increase filter-media reliability, simplify application, and improve operating performance.

Figure 15 demonstrates unique-design possibilities which pictures a "cutaway" fused-edge pressure filter leaf of bonded fabrics.

Acknowledgment

Grateful appreciation is expressed for establishment of bonded fabric industrial applications by Brosites Product Corporation and Flaherty Filter Fabrics. The Wilson Organic Chemical Company has generously cooperated in testing laboratory samples with favorable results. Sincere gratitude is expressed to the American Felt Company for its sponsorship of the bonded synthetic fiber filter cloth project since its inception in 1951.

Literature Cited

1. *Am. Soc. Testing Materials*, D-88-53 Saybolt Viscosity.
2. *Am. Soc. Testing Materials*, Committee D-13 on Textile. Materials, D-461-53 "Standard Methods of Testing Felt."
3. *Am. Soc. Testing Materials*. D-1117-53 "Testing Bonded Fabrics."
4. Brosites Products Corporation, correspondence of June, 1954 regarding the rapidity tester (modified manometer for liquid permeability determinations).
5. Brown, J. G., "Reversible Filtration," *Chem. Eng. Progr.*, **52**, 238 (1956).
6. Dickey, G. D., and C. L. Bryden, "Theory and Practice of Filtration," Reinhold Publishing Corporation, New York, p. 93 (1946).
7. Drinker, P., and T. Hatch, "Industrial Dust," McGraw-Hill Book Company, New York, p. 302 (1954).
8. Grace, H. P., "Structure and Performance of Filter Media." Parts 1 and 2, presented at the annual meeting *Am. Inst. Chem. Engrs.*, New York City (1956).
9. Harris, M., "Handbook of Textile Fibers" (1954).
10. Lauderbach, H., *Textile Research J.*, **25**, 143 (1955).
11. Soc. *Automotive Engrs.*, "Standards Handbook," p. 385 (1956).
12. Weissberger, A., *et al*, "Technique of Organic Chemistry, III," Interscience Publishers, Inc., New York (1950).
13. Worthington Corporation, "Technical Manual," Viscosity Information W-483, p. 7-21.3 (October, 1952).

Presented at A.I.Ch.E. meeting, Seattle, Washington.

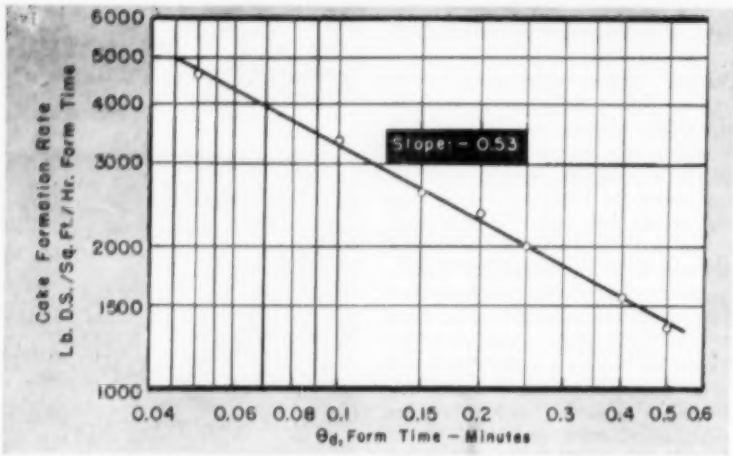


Fig. 1. Form filtration rate vs. form time; typical leaf-test data for taconite concentrates; feed solids concentration: 62.3 wt. %; form vacuum: 25 in. Hg.

MOISTURE-CONTENT CORRELATION OF ROTARY VACUUM FILTER CAKES

This method of correlating experimental results to predict full-scale cake moisture contents for continuous-filtration equipment is based on the adaptation of present theory for dewatering a consolidated filter cake so that it can be applied to data conveniently measured within the filter station. Application of the method proposed should permit the proper pilot plant procedures for obtaining the necessary data. Economic analysis of either the filter station or the entire process where operating conditions of each step within the flow sheet are intimately interrelated may be easily performed.

P. A. Nelson * | Northwestern Univ. Evanston, Illinois

D. A. Dahlstrom † | The Eimco Corp. Palatine, Illinois

Moisture content of filter cake has become of increasing importance in many industrial applications for several reasons. Where the filter cake is the final product, shipping costs per pound of dry solids naturally increase with moisture content. If the cake must be thermally dried, capital investment, operating costs, and floor-space requirements also increase with moisture content. Recovery of soluble solids or valuable liquids is increased and contamination of the filter cake is decreased as greater dewatering of the filter-feed solids is experienced. Finally, many solids must be dewatered to, or below, a critical moisture content for further processing. An example of the latter is filter cake that is balled and pelletized such as iron concentrates from low-grade taconite ores. If the moisture content is too high, balling may be impossible or may result in a soft mushy ball which will not fire properly and will yield an excessive amount of dust or fragments.

As indicated in previous literature, many factors affect final moisture content (*6, 7, 8, 9*). Chief among these are the following:

1. Size distribution of solids
2. Shape and surface characteristics of solids
3. Feed-solids concentration
4. Viscosity of the liquid
5. Dewatering time
6. Cake thickness
7. Pressure drop through the cake during dewatering
8. Air or gas rate through the filter cake
9. Filter media

Although there are many other factors that influence filter-cake moisture content, the above-listed ones are more pronounced and normally receive prime consideration.

The first four factors are concerned primarily with the filter feed and may be fixed by the process flow sheet. However, whenever process modifications can be effected, investigation of the quantitative influence of these four factors upon final moisture content should be made to determine the most economical operating conditions.

The last five factors listed are filtration conditions which may be adjusted to raise or lower the cake moisture and the filtration rate. Optimum conditions for high filtration rate do not correspond to optimum conditions for cake dewatering. For example, increasing the cake thickness to obtain drier cakes will normally decrease the filtration rate per unit area. Thus, it becomes apparent that final mois-

* P. A. Nelson is research assistant, Chemical Engineering Department.

† D. A. Dahlstrom is director of research and development.

ture content from a filter must be determined by economic considerations. Furthermore, the economic analysis must consider not only the filter station but also the process steps prior to, and following, filtration as they may be significantly influenced by the filter-feed requirements and final cake moisture content.

Dewatering of filter cake from continuous filters has been treated by theoretical and empirical methods (*1, 2, 5, 6, 7, 8, 9*). The empirical methods are not reliable for untried applications and the theoretical methods usually require prediction of filter cake variables which are difficult to determine. Therefore, an analysis method, based upon theoretical considerations which would permit the correlation of data from relatively simple test procedures to predict full-scale filter cake moisture contents, would be of definite advantage. Furthermore, the method must predict results over the proper range of feed-slurry and filter-station operating conditions. These results used in conjunction with filtration capacity per unit area will allow a complete plant economic analysis to determine final design.

Correlation Method

The method for utilizing Equation (*22*) is as follows.

a. Make test runs with a pilot plant filter or on leaf test equipment varying the pertinent filtration variables such as form vacuum, form time, drying vacuum, drying time, drum speed, submergence, and feed concentration. (The form vacuum and drying vacuum need not always be investigated where low air rates through the filter cake are encountered. In such cases economics will usually dictate the highest practical operating vacuums of 24-26 in. Hg at sea level conditions.)

b. Plot the per cent cake moisture vs. the approach factor, $\theta_d R_r/B \ \Delta P/\Delta P'$, using data within narrow limits of form and dry vacuum. Also use narrow limits on any other variable which appears to affect the correlation seriously. Determine the magnitude of the approach factor at which the curve reaches the residual moisture.

c. By empirical methods, correlate the effect of the filtration variables on the residual moisture by analyzing the data with approach factors greater than that determined in part b.

d. From the information determined in part c, calculate the residual moisture of the filter cakes for the runs having approach factors of less than that necessary to reach the residual moisture.

e. Calculate the difference between the actual moisture and the calculated residual moisture ($\%M - \%M_r$) for each filter cake. Plot this value vs. the approach factor.

f. An analysis of the graphs of c and e, along with filtration rate and cost data, will indicate the most economical number of filters necessary and the proper filtration conditions.

Verification of the Proposed Method

One of the key operations in the preparation of taconite iron-ore concentrate for the blast furnace is pelletizing. The moisture content of the filter cake fed to the balling drums is an important factor in the controllability and cost of the operation. If the moisture content is above a certain critical limit, the size of the pellet

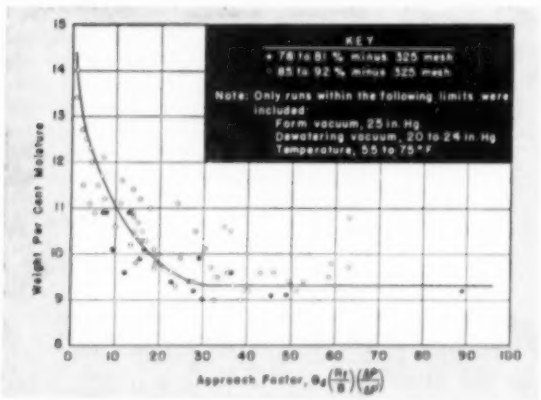


Fig. 2. Filter-cake moisture content vs. approach factor; filtration of taconite concentrates.

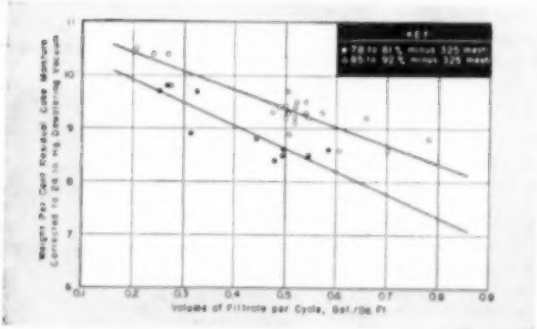


Fig. 4. Residual cake moisture vs. filtrate volume per cycle; only runs within the following limits were included; approach factor greater than 30; dewatering vacuum 20 to 24 in. Hg.

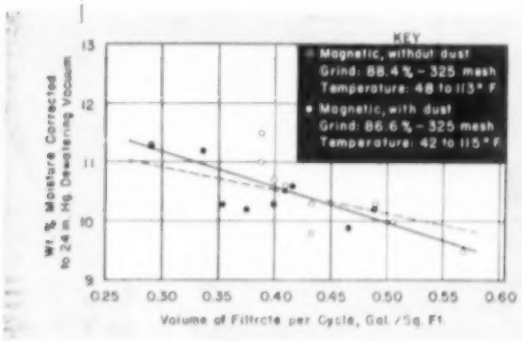


Fig. 5. Cake moisture content vs. volume of filtrate per cycle as varied by temperature change; filtration of taconite concentrates. Note: temperature was only independent variable. Dashed line shows slope from Figure 3; solid line is curve of best fit.

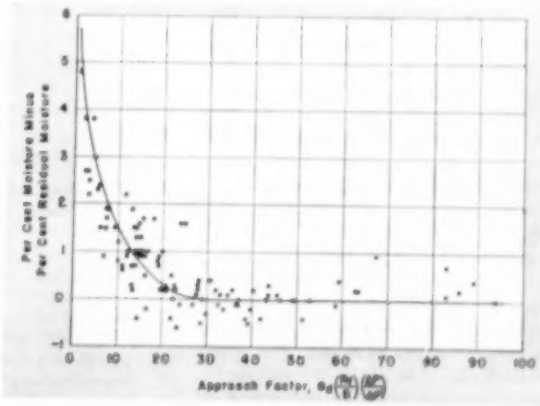


Fig. 6. Filter-cake moisture content minus residual moisture vs. approach factor filtration of taconite concentrates.

Table A.

Variable	Selected test points
Form time	.05, .10, .15, .20, .25, .40, .50 min.
Drying time	.05, .10, .15, .20, .25, .35, .50, .75, 1.00, 1.25, 1.50 min.
Vacuum level	Form—5 to 25 in. Drying—5 to 25 in.
Feed temperature	45 to 113° F.
Size distributions of feed solids	Approx. 70 to 95%—325 mesh
Feed-solids concentration	Approx. 40 to 75% solids
Filter media	Saran 601
Cake thickness	5/16 to 1 in.

is difficult to control and the balls tend to stick together. For the best control it is preferable to produce filter cake that is slightly low in moisture for the pelletizing drums because the moisture content can be easily raised to the exact value desired.

The Reserve Mining Company, which processes taconite ore, established a research program with the aid of the Eimco Corporation to investigate the effect of the following variables on the cake moisture: drying time, cake thickness, vacuum level, feed temperature, size distribution of feed solids, feed-solids concentration, filter media, air rate through the cake, and the effect of certain additives. The intial tests were made on leaf test laboratory equipment and the results were checked on commercial-sized filters. Data were correlated by the method of Piros, Silverblatt and Dahlstrom with good results in a paper by Henderson, *et al.* (*6*). The data from this investigation were available to the authors to substantiate the theoretically derived correlation method (*3*).

One filtration variable at a time was varied over the ranges shown in Table A while the remaining variables were held constant.

Results of the laboratory work were checked by tests on an Agidisc filter and a drum filter. Because these filters were in the production line, it was not possible to vary the conditions over wide limits. The test samples were taken by cutting 0.1-sq. ft. samples from each side of the six discs on the Agidisc filter and ten 0.1-sq. ft. samples from the face of the drum filter. Although a few leaf tests were made with nonmagnetic material and with material containing return dust, runs made only with magnetic feed and without return dust were considered in this study. A complete discussion of the experimental procedures and results will be found in the original paper (*6*).

Theoretical Development

Piros, Brusenback, and Dahlstrom derived an empirical factor,

$$\frac{\text{cu.ft./min.}}{\text{sq.ft.}_{\text{avg.}}}\left(\frac{\Delta P}{L}\right)(\theta_d),$$

against which cake moistures could be correlated (*7*). Silverblatt and Dahlstrom (*9*) revised the above correlation factor to the following

$$\left(\frac{\text{cu.ft./min.}}{\text{sq.ft.}}\right)\left(\frac{\Delta P}{L}\right)\left(\frac{\theta_d}{\mu}\right)$$

In many cases the correlation factor has been found to be useful for estimating the best operating range for filtration variables.

The problem of the removal of a wetting fluid from a porous solid by the flow of a nonwetting fluid was treated in a more theoretical fashion in papers by Brownell and Katz (*2*) and Brownell and Gudz (*1*). These articles proposed the theory that as a wetting fluid is removed from a porous medium by a nonwetting fluid such as air, an equilibrium or residual moisture is approached below which the cake cannot be dewatered under the existing conditions. This equilibrium is due to the balancing of the driving force, the air pressure gradient, by capillary force.

Since it is usually not economical to dewater the cake to equilibrium, the rate at which the filter-cake moisture approaches the residual moisture is important also. Brownell and Gudz derived the following expression relating the saturation to the length of the drying part of the cycle and to the cake and filtrate variables (*1*).

$$d\theta_d = \frac{-xL^2\mu\left(\dfrac{1-S_r}{1-S_rS_e}\right)^2}{K(\Delta P')S_e^{\,y}}\,dS_e \qquad (1)$$

Equation (1) in integrated form becomes

$$\theta_d = \frac{-xL^2\mu}{K(\Delta P)}\int_1^{S_e}\left(\frac{1-S_r}{1-S_rS_e}\right)^2\frac{dS_e}{S_e^{\,y}} \qquad (2)$$

Since

$$S_e = \frac{S-S_r}{1-2S_r+SS_r}$$

$$S = f\left(\frac{\theta_d K(\Delta P)}{xL^2\mu},\ S_r,\ y\right) \qquad (3)$$

The main drawback of the above equation is the difficulty of measuring and predicting the cake permeability, thickness, and porosity.

Equation (3) was employed as a basis for the development of the correlation method. It indicates that there are three factors which affect the moisture content of a filter cake.

1. **The residual or equilibrium saturation, S_r: the lowest saturation which can be reached for a particular filter cake at a given pressure gradient.**
2. **The approach factor, $\theta_d K(\Delta P)/\mu x L^2$: the factor determining the nearness of approach to the equilibrium saturation. For an approach factor of zero (for instance $\theta_d = 0$) the saturation is unity. With increasing values of the approach factor, the saturation approaches the residual saturation.**
3. **The y factor: a factor depending on the material only and influenced primarily by particle shape, surface area, and size characteristics.**

Since the function relating the approach factor, the residual saturation, and the y factor has not been defined, the saturation (S) and residual saturation (S_r) may be replaced with per cent moisture ($\%M$) and per cent residual moisture ($\%M_r$) respectively, without changing the validity of the expression.

$$\%M = f(F_a,\ \%M_r,\ y) \qquad (4)$$

If the resistance of the filter cloth is negligible, Darcy's equation may be utilized to eliminate the permeability, K, from the approach factor (*4*).

$$v = K\left(\frac{\Delta P'}{L\mu}\right) \quad \text{or} \quad K = \frac{v\mu L}{\Delta P} \qquad (5)$$

Eliminating K in the approach factor yields:

$$F_a = \frac{\theta_d v_f \Delta P}{xL\Delta P'} \qquad (6)$$

It is not convenient to determine the filtrate rate at the end of the form time but fortunately v_f can be expressed in terms of the average form filtrate rate for incompressible cakes.

$$L = \frac{wV}{A\rho_s} \qquad (7)$$

Combining the above equation with Darcy's equation:

$$v = \frac{dV}{Ad\theta_f} = \frac{\rho_s K\Delta P'}{w\mu}\left(\frac{A}{V}\right) = c\,\frac{A}{V} \qquad (8)$$

Data from Experimental Test Runs

Preliminary plots of the data showed that several factors influenced the residual moisture. Therefore, it was necessary to follow closely the correlation procedure outlined in Correlation Method, discussed previously in this article. One of the conditions for applying the correlation method derived above was that the form-filtration rate should be inversely proportional to the square root of the form time. A plot was made of the form-filtration rate expressed as pounds dry solids per square foot per hour of form time vs. the form time on log-log paper (Figure 1). The slope of the straight line through the data was —0.53 compared to the ideal value of —0.5.

In order to find the relationship of the variables to the residual moisture, it was first necessary to determine the magnitude of the approach factor required to reach the residual moisture value as suggested in part b of the Correlation Method. This was done by plotting per cent cake moisture vs. the approach factor in Figure 2 for a selected group of runs which were believed to have approximately the same residual moisture. A study of the data indicated that the variables form vacuum, drying vacuum, and temperature had a marked effect on the residual moisture. Therefore, only runs performed at a form vacuum of 25 in., a drying vacuum of 20 to 24 in., and at temperatures between 55 and 75° F. were plotted on this graph. Although some data deviated quite far from the line, it is clear that the residual moisture is reached at an approach factor of about 30. Figure 2 serves the single purpose of determining the approach factor at which the residual moisture is reached. Some of the scattering of the points about

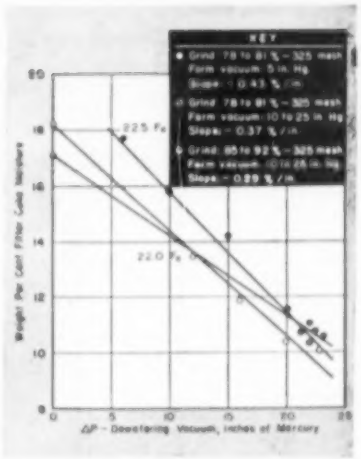


Fig. 3. Residual cake moisture vs. dewatering vacuum. Unless noted otherwise, only runs within the following limits were included: approach factor, Fa, greater than 30; filtrate volume per cycle 0.15 to 0.35 gal./sq.ft.

For a single cycle of a rotary filter $\rho_s K \Delta P^{n'}/w\mu$ may be considered a constant (c). Therefore, integration of Equation (8) yields:

$$\theta_f = \frac{1}{2c}\left(\frac{V}{A}\right)^2 = \frac{c}{2v^2} \qquad (9)$$

$$v = \sqrt{\frac{c}{2\theta_f}} \qquad (10)$$

The average form filtrate rate, R_f, (expressed as volume per unit area per unit time of cake formation), can be related to the superficial filtrate velocity, v, by the following equation.

$$R_f = \frac{\int_0^{\theta_f} v\,d\theta_f}{\theta_f} \qquad (11)$$

Although the filtrate continues to flow from the cake during the dewatering part of the filtration cycle, the volume of filtrate forced out of the cake during dewatering is assumed to be negligible in comparison with the total filtrate volume per cycle for the purpose of this analysis. R_f is therefore approximately equal to the total filtrate volume per unit area per cycle divided by the form time.

Substituting Equation (10) into Equation (11)

$$R_f = \frac{\sqrt{\frac{c}{2}}}{\theta_f}\int_0^{\theta_f} \frac{d\theta_f}{\sqrt{\theta_f}} = \sqrt{\frac{2c}{\theta_f}} \qquad (12)$$

From Equation (10)

$$v_f = \sqrt{\frac{c}{2\theta_f}}$$

Therefore,

$$R_f = 2v_f \qquad (13)$$

Substitution of $\frac{1}{2} R_f$ for v_f in the approach factor, Equation (6), yields:

$$F_a = \frac{\theta_d R_f \Delta P}{2x L \Delta P'} \qquad (14)$$

Now,

$$L = \frac{B}{\rho_s} \qquad (15)$$

Making this substitution in Equation (14) yields:

$$F_a = \frac{\rho_s \theta_d R_f}{2xB}\frac{\Delta P}{\Delta P'} \qquad (16)$$

Rewriting Equation (4) with the revised approach factor,

$$\%M = f\left(\frac{\rho_s \theta_d R_f \Delta P}{2xB\Delta P'},\ \%M_r,\ y\right) \qquad (17)$$

For incompressible cakes $\rho_s/2x$ is constant. Therefore,

$$\%M = f'\left(\frac{\theta_d R_f}{B}\frac{\Delta P}{\Delta P'},\ \%M_r,\ y\right) \qquad (18)$$

The approach factor as it appears in Equation (18) can be easily evaluated from leaf test data or pilot plant rotary-filter data.

The feed concentration has a marked effect on the ratio R_f/B and, therefore, variations in feed concentration cannot be ignored. To illustrate the effect of the feed concentration on the R_f/B ratio, consider the following transformation:

$$R_f\theta_f = \frac{B}{w} \text{ or } \frac{R_f}{B} = \frac{1}{w\theta_f} \qquad (19)$$

w can be expressed in terms of the feed-solids concentration % (d.s.) and the cake moisture (%M) assuming a negligible amount of suspended solids in the filtrate.

$$\frac{1}{w} = \frac{1}{\rho}\left(\frac{100 - \%\text{ d.s.}}{\%\text{ d.s.}} - \frac{\%M}{100 - \%M}\right) \qquad (20)$$

The term $\%M/100 - \%M$ may be neglected for very dry cakes. In other cases, a rough estimate is satisfactory. Note that a change in the % d.s. of the feed will cause a greater change proportionately in w and therefore in the ratio R_f/B.

Utilizing Equation (19) to eliminate R_f/B in the approach factor results in the following expression:

$$F_a = \frac{\theta_d R_f}{B}\frac{\Delta P}{\Delta P'} = \frac{1}{w}\frac{\theta_d}{\theta_f}\frac{\Delta P}{\Delta P'} \qquad (21)$$

$$\%M = g(F_a,\ \%M_r,\ y) \qquad (22)$$

The main assumptions in the above analysis were (1) an incompressible filter cake, (2) negligible filter-cloth resistance, and (3) uniform and unchanging cake specific permeability. These assumptions are not justified for filtration calculations in general. However, investigation of the effect of deviations from these assumptions on the value of the approach factor and the cake moisture indicate that moderate variations from the assumptions do not invalidate the derived equations for practical purposes. The two cases for which the equations were tested in this investigation corroborate these observations.

Table 1.—Comparison of Calculated and Observed Cake Moisture for Agidisc and Drum Filters

Date Run No.	Filter type	Time-min. form	Time-min. dry	Vacuum in. Hg. form	Vacuum in. Hg. dry	% −325 mesh	% Feed solids	Fe	Moisture content calc.	Moisture content observed
9/20/55—1	A	.15	.26	25	23	89.1	56	7.6	11.9%	10.8 %
—2	A	.15	.26	25	23	89.1	52	9.2	11.3	10.8
—3	A	.18	.31	25	23	89.1	57	7.3	11.8	10.5
—4	A	.20	.34	25	23	89.1	55	8.0	11.5	10.4
—5	A	.22	.37	25	23	89.1	55	7.9	11.4	10.5
9/21/55—1	D	.30	.55	22	20	83.3	45	13.2	10.4	10.8
—2	A	.16	.27	25	23	83.2	58	6.7	11.8	10.6
—3	A	.18	.32	25	23	83.2	56	7.8	11.3	10.4
—4	A	.12	.20	25	23	83.2	56	7.3	11.8	10.9
9/22/55—1	A	.12	.21	25	23	86.0	56	7.6	12.0	10.7
—2	A	.16	.27	25	23	86.0	56	7.4	11.9	10.4
—3	A	.18	.32	25	23	86.0	55	8.2	11.6	10.3
—4	A	.21	.35	25	23	86.0	56	7.3	11.7	10.5
—5	D	.30	.55	22	20	86.0	44	13.9	10.8	10.3
9/23/55—1	D	.15	.61	22.5	20	85.0	42.5	32.0	10.5	11.2
—2	D	.15	.61	22.5	20	85.0	50	22.8	10.8	10.7
—3	D	.15	.61	22.5	20	85.0	57	16.4	11.5	10.9
—4	D	.15	.61	22.5	20	85.0	47	26.1	10.6	10.7
—5	D	.15	.61	24	22	85.0	47	26.9	9.9	10.5
9/24/55—1	A	.16	.28	25	23.5	81.5	59	6.8	11.4	10.5
—2	A	.15	.25	25	23.5	81.5	59	6.4	11.4	10.6
—3	A	.15	.27	25	23.5	81.5	57	7.7	11.1	10.5
—4	A	.19	.32	25	23.5	81.5	57	7.2	10.9	10.4
9/25/55—1	A	.15	.24	25	23.5	85.1	56	7.2	11.8	10.8
—2	A	.18	.31	25	24	85.1	57	7.5	11.5	10.6
—3	A	.15	.26	25	23.5	85.1	57	7.4	11.8	10.7
—4	A	.12	.21	25	23.5	85.1	57	7.5	12.0	11.0
9/26/55—1	A	.15	.26	25	23.5	79.0	57	7.4	11.1	10.5
—2	A	.10	.18	25	23	79.0	58	7.1	11.7	10.8
—3	A	.15	.24	25	23.5	79.0	59	6.2	11.5	10.6
—4	A	.19	.33	25	23.5	79.0	59	6.7	11.1	10.5

A = Agidisc filter
D = Drum filter

Avg. value for calculated minus observed cake moisture:
Agidisc filter: +0.96%
Drum filter: −0.10%

Avg. abs. error:
Agidisc filter: 0.96%
Drum filter: 0.43%

the line is due to using data for the plot which covered a range of a variable that affected the residual moisture. For instance, the range covered by the drying vacuum, 20 to 24 in. Hg, was later shown to cause a variation in the moisture content of about 1.5%.

With the knowledge that all runs having approach factors greater than 30 resulted in a filter cake at its residual moisture, it was possible to determine the factors controlling the residual moisture by empirical means (part c of Correlation Method). By trial-and-error plotting of the data it was found that in this case the residual moisture was controlled by four variables: (1) drying vacuum, (2) volume of filtrate per cycle, (3) particle-size distribution of the solids in the feed, and (4) form vacuum for vacuums below 10 in. Hg. Above 10 in. Hg the form vacuum appeared to have no effect on the residual moisture not already accounted for in the volume of filtrate per cycle.

Figures 3 and 4 show the results of this analysis. As shown in Figure 3 the drying vacuum had a marked effect on the cake moisture. For this graph the data with approach factors over 30 were divided into three groups: (1) coarse particle-size distribution and 5 in. form vacuum, (2) coarse particle-size distribution and 10 to 25 in. form vacuum, and (3) fine particle-size distribution and 10 to 25 in. form vacuum. The points at zero drying vacuum were obtained from cake- and slurry-density data by a calculation assuming a rigid filter cake. The particle density, obtained from hydrometer readings and solids determinations on several batches of feed, was found to be 4.42 g./cc. An average bulk density for dry filter cake was calculated for the fine and the coarse material from the values of the cake thickness and dry cake weight obtained for each run. From the bulk density of dry cake and the particle density, the cake moisture at 100% saturation was calculated to be 17.1% for the finely ground feed and 18.2% for the coarser feed. The higher moisture for the coarser feed is probably due to looser packing which means more void space available for water.

From the slopes obtained in Figure 3 it was possible to recalculate all the residual cake moistures to that expected at a 24-in. Hg drying vacuum. The corrected moisture values were plotted vs. the volume of filtrate per cycle in Figure 4 for runs made at approach factors greater than 30. The correlation of the residual moisture with the volume of filtrate per cycle was entirely empirical and could not be expected to be valid outside the range of variables for which the plot was made. The volume of filtrate per cycle is a function of the viscosity of the filtrate and therefore a function of the temperature. However, the only residual-moisture data available for the plot of residual moisture vs. volume of filtrate per cycle were taken over a relatively narrow range of temperatures. It was therefore necessary to determine whether the effect of the temperature on the cake moisture was properly measured by the effect of the volume of filtrate per cycle on the cake moisture.

Figure 5 shows a plot of the cake moisture vs. the volume of filtrate per cycle for two sets of runs in which the only independent variable was the feed temperature. (The approach factor of 15 for these runs was too low to permit plotting with the residual moisture data in Figures 3 and 4.) The slope of the line of best fit is almost the same as that of the line for the fine feed distribution from Figure 4. Therefore, the variation in cake moisture due to temperature change was considered to be accounted for by the variation in the volume of filtrate per cycle.

In the next step in the correlation (part d of Correlation Method), Figures 3 and 4 were used to calculate the residual moisture for each of the runs at the drying vacuum level and volume of filtrate per cycle at which each run was made. This calculation was made for all the data regardless of whether the approach factor was above or below that necessary to reach the residual moisture. The difference between the observed moisture and the calculated residual-moisture content of each cake was plotted vs. the approach factor in Figure 6. The average deviation of the data from the curve, 0.39 percentage points, is not much greater than the error expected in measuring the moisture content.

Application of Results

In order to apply the relationships derived for the taconite iron-ore data, it was necessary to determine the volume of filtrate per cycle as a function of independent variables. This was done for the finely ground feed (85-92% —325 mesh) as an example by the following method:

The weight of filter cake per hour of form time was averaged for each set of runs made from the same batch of feed at the same form time. This average was "corrected" to a form time of 0.15 min. by applying the equation,

$$\frac{R_a(0.15)}{R_a(\theta_f)} = \left(\frac{0.15}{\theta_f}\right)^{-0.53} \qquad (23)$$

The coefficient, —0.53, is the slope of the log-log plot of cake rate vs. form time in Figure 1. The cake rate corrected to 0.15 form time, $R_a(0.15)$, vs. the feed-solids concentration is plotted in Figure 7. The volume of filtrate per cycle can be calculated from $R_a(0.15)$ and the equation:

$$V = \frac{R_a(0.15)}{w}\,\frac{\theta_f}{60}\left(\frac{0.15}{\theta_f}\right)^{0.53} \qquad (24)$$

$$\frac{1}{w} = \left(\frac{100 - \%\ \text{d.s.}}{\%\ \text{d.s.}} - \frac{\%M}{100 - \%M}\right)$$

Finally, the relationship between the cake moisture and the independent filtration variables is shown in Figure 8. To construct this graph, the approach factor, $1/w\ \theta_d/\theta_f\ \Delta P/\Delta P'$, was calculated for each point on the graph at set values of the θ_d/θ_f ratio, the feed-solids concentration, and the $\Delta P/\Delta P'$ ratio. For a set value of form time and the $R_a(0.15)$ value from Figure 7, the volume of filtrate per cycle was calculated from Equation (24). With Figures 4 and 6 the $\%M_r$ and $\%M - \%M_r$ values were determined, and by addition of these values, the per cent cake moisture was also determined. The procedure was repeated for several points along each curve drawn.

By this same method the filter-cake moistures for the plant-size filters were calculated at the conditions of actual test runs and compared with the observed cake moistures. Results are shown in Table 1. Predicted values for the Agidisc filter were high by an average of 0.96% moisture but for the drum filter they were not biased. Apparently the leaf-test apparatus is a better indication of drum-filter operation than Agidisc operation. It is probable that the Agidisc has the same relationship between $\%M$-$\%M_r$ and the approach factor as the leaf test and the drum filter but with a different residual-moisture relationship. The low approach factors for the Agidisc filter indicate that a considerably drier cake could be obtained at higher drying time to form time ratios.

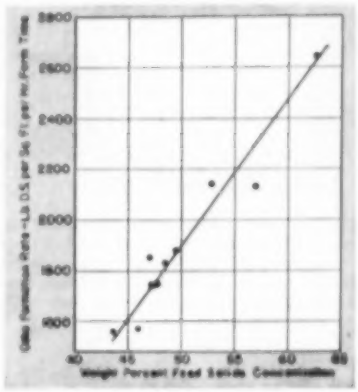


Fig. 7. Filtration rate vs. feed solids concentration; form vacuum: 25 in. Hg, grind: 85 to 92% — 325 mesh; cake formation rate corrected to 0.15 min. form time.

Industrial Application to Plant Economic Analysis

To illustrate the application of the correlation method to provide the necessary data for both a plant scale-up and economic analysis, the dewatering of corn gluten will be taken. In a modernization program, it was decided to investigate the use of centrifuges to separate gluten from starch as a possible replacement for settling tables and settling tanks. Also it was proposed that rotary vacuum filters replace plate-and-frame presses for dewatering. The final step, thermal drying, was to remain unchanged.

Operating results over a range of conditions for both the centrifugal separators and the filters had to be developed for the following reasons:

1. Centrifugal separator capacity per unit would decrease as the gluten purity (as measured by % protein on a dry solids basis) and suspended-solids concentration increased in the centrifuge product.
2. Filtration capacity per unit area would be expected to increase with an increase in suspended-solids concentration from the centrifugal separators. Capacity could also be influenced by purity of the gluten.
3. Dryer capacity would be a function of the moisture content of the filter cake which might be influenced by filter capacity, filter feed-solids concentration, gluten purity, feed temperature, etc.

From the above, it is apparent an economic analysis around the entire flow sheet is imperative as the operating conditions on one processing unit vitally affect the cost and results of the others. The analysis to be given will be concerned only with the filtration step, but filtration capacity and filter-cake moisture content as a function of all operating variables of the filter station will be developed.

A pilot plant for the filtration of corn gluten was constructed at the Argo, Illinois, refinery of Corn Products Refining Company. The pilot plant consisted of a 3-ft. diam. by 2-ft. face Eimco string discharge filter with all necessary auxiliary equipment.

Results of this work were reported in an earlier paper and the raw data were available to the authors (*8*). Conclusions for filter-cake moisture content in the previous study were based on the empirical correlation method of Silverblatt and Dahlstrom (*9*) and several approximations had to be employed. Thus, it was decided to apply the preceding development to determine if more accurate and dependable results for moisture content could be predicted. The reader is referred to the earlier paper for experimental procedures, test equipment, and results (*8*).

One of the conditions for applying the correlation method derived earlier was that form-filtration rate should be inversely proportional to the square root of the form time. A log-log plot of form-filtration rate as a function of form time yielded slopes of —0.55 for the various parameters indicating a close agreement. Accordingly, the theoretical development should apply quite closely.

Preliminary studies indicated that cake formation and dewatering vacuum had little if any effect on the residual-moisture content. Furthermore, because of the low air rates through the cake, it was readily ap-

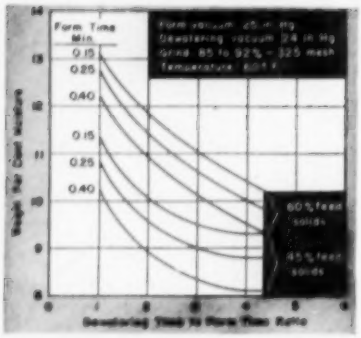


Fig. 8. Cake moisture as a function of dewatering time and form time; taconite iron ore concentrates. Note: to obtain moisture content for dewatering vacuums other than 24 in. Hg, use formula % moisture = % moisture from graph − 0.29 (vac. − 24).

parent that practical high operating vacuums of 24-26 in. of Hg vacuum could be easily justified from an economic standpoint. Thus, the majority of runs were confined to high vacuums. From the paper of Schepman, *et al.*, it was known that temperature did not have an appreciable influence on final cake moisture (*8*). As a first assumption, therefore, the protein concentration of the feed solids was taken to be the only variable affecting the residual-moisture content.

The approach factor, $\theta_d R_f/B\ \Delta P/\Delta P'$, was simplified by dropping $\Delta P/\Delta P'$ because form and dry vacuums were always approximately equal. By trial and error, it was found that a plot of pounds of moisture per pound of dry cake solids vs. the log of the approach factor was a straight line for narrow protein ranges. Coupling this fact with the slight effect of the protein concentration on the residual moisture, it appeared that an equation of the following type could represent the data:

$$Y = b_1 \log Fa + b_2(\%P) + c' \qquad (25)$$

The equation developed statistically by multiple-regression analysis was:

$$Y = -0.7903 \log Fa + 0.00598(\%P) + 2.524 \qquad (26)$$

The 95% reliability limits for estimating Y in Equation (*26*) was ±0.1300. Figure 9 is a graph of the pounds of moisture per pound of dry-cake solids corrected to 70% protein vs. the log of the approach factor. The even distribution of the points about the line illustrates the validity of the type of regression equation used to correlate the data. It will be noted also that the residual-moisture content was never reached for any of the runs as was experienced with the taconite concentrates.

In order to determine whether any of the filtration variables other than per cent protein affected the residual-moisture content and to test the validity of the correlation method, a multiple-regression correlation was made with the difference of the moisture content from that calculated from the regression equation, ΔY, as the dependent variable. The independent variables were:

X_1 = drying time, min.
X_2 = form-filtration rate, gal./hr. form time/sq. ft.
X_3 = cake thickness parameter, lb. dry solids/(sq.ft.)(cycle).
X_4 = key number, the number of a pair of runs in the sequence of tests made from a batch of feed.
X_5 = pressure drop across filter cake, in. Hg

It should be noted that

$$Fa = \frac{R_f\theta_d}{B} = \frac{X_1X_2}{X_3}$$

Thus the variables making up the approach factor were tested for any further influence on the cake moisture. The regression equation analyzed was:

$$\Delta Y = b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + c'' \qquad (27)$$

The analysis showed that pressure drop, cake thickness parameter, and key number had an insignificant effect on the predicted moisture content. Thus, only drying time and form-filtration rate have any significance other than expressed by the approach factor. The regression equation for estimating ΔY with these two variables was found to be:

$$\Delta Y = -0.0246\ X_1 + 0.00248\ X_2 + 0.0178 \qquad (28)$$

The standard error for estimating ΔY from this equation was 0.0595. This compares to the standard error for estimating Y of 0.0650. The slight improvement in the variance of the estimation coupled with the small coefficients in the equation for ΔY indicates that the variable drying time and form-filtration rate have a negligible influence on the cake moisture aside from their effect on the approach factor. This result was taken as further proof of the validity of the proposed correlation method.

Equation (*26*) can now be employed in predicting full-scale results. As shown earlier, in Equation (*21*), the approach factor Fa can be modified in this case to,

$$Fa = \frac{\theta_d R_f}{B} = \frac{1}{w}\frac{\theta_d}{\theta_f}$$

In this instance,

$$\frac{1}{w} = \frac{1}{\rho}\left(\frac{100 - \text{wt.\% d.s.}}{\text{wt. \% d.s.}} - Y\right)$$

Cake formation and dewatering times θ_d and θ_f are more conveniently expressed in terms of percentage of cycle time.
Therefore:

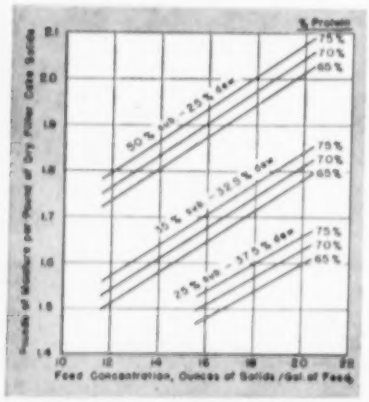
$$Fa = \frac{1}{w}\left(\frac{\%\text{ dewatering time}}{\%\text{ form time}}\right) \qquad (29)$$

For each submergence of a full-scale filter, the per cent of cycle time that can be devoted to cake dewatering will be known. A value of Y can be calculated from Equations (*26*) and (*29*) for any operating condition by trial-and-error calculation. Figure 10 was developed on this basis.

Figure 10 is a plot of pounds of moisture per pound of dry solids as a function of feed-solids concentration of gluten in ounces per gallon. Parameter of per cent submergence and per cent dewatering time, and protein per cent are included. Three different submergences for standard drum filters have been employed. As submergence and feed-solids concentration increases, the cake will be wetter and require more heat for subsequent drying.

Final data needed to supply the necessary information for the plant economic analysis as regards the filter station is supplied by Figure 11. This is a plot of filtration rate expressed as pounds of dry solids per hour per square foot as a function of feed-gluten concentration with parameters of filter cycle time and was developed in the earlier paper (*8*). The plot is restricted to 35% submergence and protein concentrations of 60-75%. Similar plots were developed for 25 and 50% submergence as well as for other protein concentrations.

Fig. 10. Effect of feed concentration on corn gluten filter-cake moisture; parameters of % protein and % submergence and % dewatering time.



From the plots of Figures 10 and 11, it is possible to predict filtration requirements for any feed-solids concentration and protein content and simultaneously determine cake moisture content. Thus, required duty of the centrifugal separators and the thermal-drying step can be calculated for each basis. Accordingly, a complete plant economic analysis can be made in order to arrive at the lowest total operating cost.

Notation

A = area of filtration

B = weight of dry cake solids per unit area per cycle

b_1, b_2, b_3, b_4, b_5 = constants

$\left(\frac{\text{cu.ft./min.}}{\text{sq.ft.}}\right)_{avg}$ = cubic feet of air measured at average pressure through the cake per minute per square foot

$\left(\frac{\text{cu.ft./min.}}{\text{sq.ft.}}\right)$ = cubic feet of air measured at 32° F., 29.92-in. Hg

c = constant for an incompressible cake $= \frac{\rho_s K \Delta P'}{w\mu}$

c', c'' = constants

Fa = approach factor $= \frac{\theta_d K \Delta P}{\mu x L^2}$

$\frac{R_f \theta_d \Delta P}{B \Delta P'}$ or $\frac{1 \theta_d \Delta P}{w \theta_f \Delta P'}$

f, f', g = functional notations

K = specific cake permeability

L = cake thickness

MPR = filter cycle time, minutes per revolution

ΔP = pressure drop through cake during dewatering

$\Delta P'$ = pressure drop during cake formation

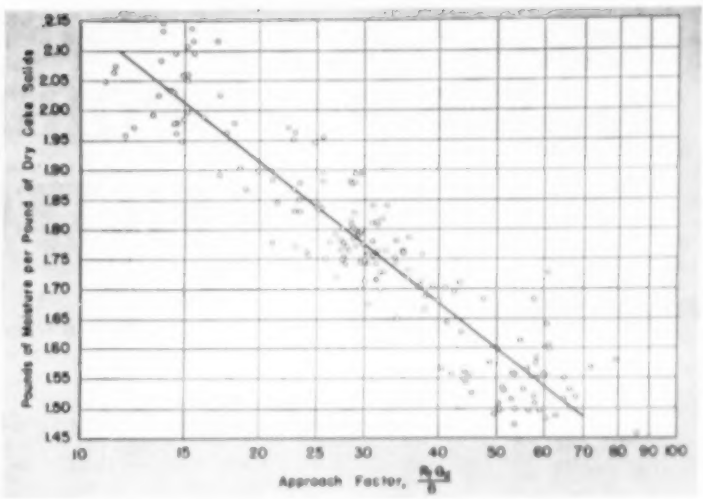


Fig. 9. Corn gluten filter-cake moisture vs. approach factor; data corrected to 70% protein.

R_s = cake form filtration rate, pounds of dry cake solids per square foot per hour cake formation time

R_f = form filtrate rate, volume per unit area per unit cake formation time

S = fraction of voids containing wetting fluid

S_e = (voids containing wetting fluid in flow)/(voids containing both fluids in flow

S_r = residual saturation at equilibrium

V = volume of filtrate

v = superficial velocity

v_f = superficial filtrate velocity at end of cake formation time

w = weight of dry cake solids per unit volume of filtrate

x = filter cake porosity = $\frac{\text{volume of void space}}{\text{total volume of cake}}$

Y = pounds of moisture per pound of dry cake solids

y = exponent depending on particle size

% $d.s.$ = weight % dry solids in filter feed

% M = weight % moisture in filter cake

% M_r = weight % residual moisture in filter cake

θ_d = cake dewatering time

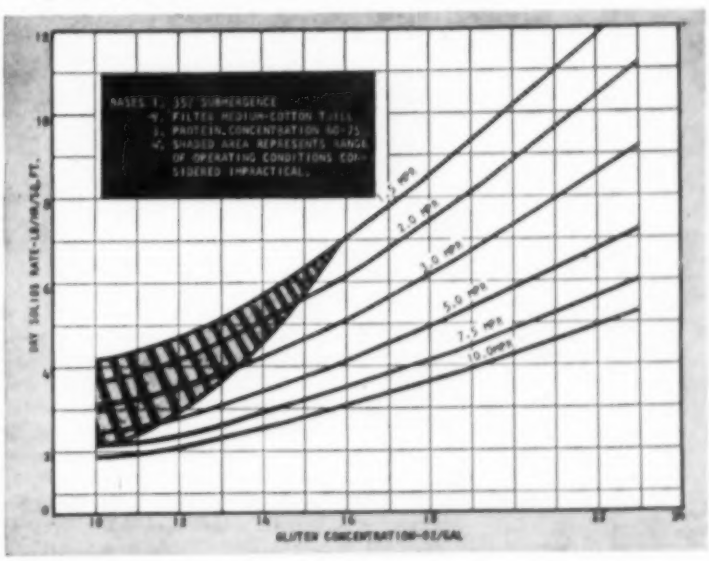
θ_f = cake formation time

μ = viscosity of filtrate or liquid

ρ = density of filtrate, weight per unit volume

ρ_s = cake bulk density, dry solids basis, weight per unit volume

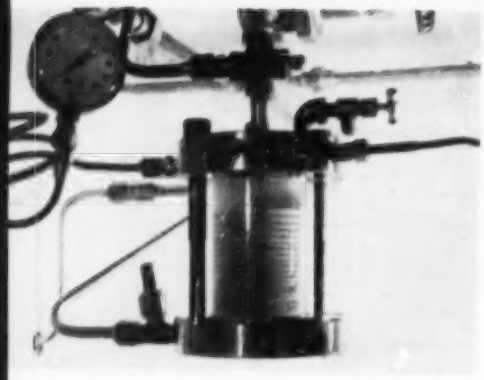
Fig. 11. Dry solids rate as function of gluten concentration filtration of corn gluten.



Literature Cited

1. Brownell, L. E., and G. B. Gudz, *Chem. Eng.*, **56**, 112 (1949).
2. Brownell, L. E., and D. L. Katz, *Chem. Eng. Progr.*, **43**, 601 (1947).
3. Cornell, C. F. and D. A. Dahlstrom, private report by The Eimco Corporation to Reserve Mining Company, Babbitt, Minnesota.
4. Darcy, L., "*Les Fontaines Publiques of the Ville of Dijon*," Victor Delmont, Paris (1856).
5. Dombrowski, H. S. and L. E. Brownell, *Ind. Eng. Chem.*, **46**, 1207 (1954).
6. Henderson, A. S., C. F. Cornell, A. F. Dunyon, and D. A. Dahlstrom, *Min. Eng.*, **9**, 349, (1957).
7. Piros, R. J., R. A. Brusenback, and D. A. Dahlstrom, *Min. Eng.* **4**, 1236, (1952).
8. Schepman, B. A., B. Martin, and D. A. Dahlstrom, *Chem. Eng. Progr.* **52**, 423, (1956).
9. Silverblatt, C. E., and D. A. Dahlstrom, *Ind. Eng. Chem.*, **46**, 1201, (1954).

Presented at A.I.Ch.E. meeting, Seattle, Washington.



Typical photograph of a cake banded at equal solids intervals during constant-rate filtration.

DISTRIBUTION OF POROSITY IN FILTER CAKES

F. B. Hutto, Jr. | Johns-Manville Research Center, Manville, New Jersey

A study of changes in porosity during the filtration process was made by forming a banded filter cake inside a transparent filter and photographically recording the positions of the various bands during the course of filtration. The author concludes that porosity decreases relatively rapidly near the liquid face of the cake and then continues at a slower, almost linear rate of decrease down to minimum porosity at the septum.

One of the most challenging subjects in the field of filtration is the study of porosity (ϵ) of filter cakes. A prime factor in the filtration process, porosity is defined as the volume of voids divided by the total cake volume, or as the void fraction of the cake. While there are other factors involved, porosity gives some measure of the *amount* of filter-cake free space through which liquid may flow.

History

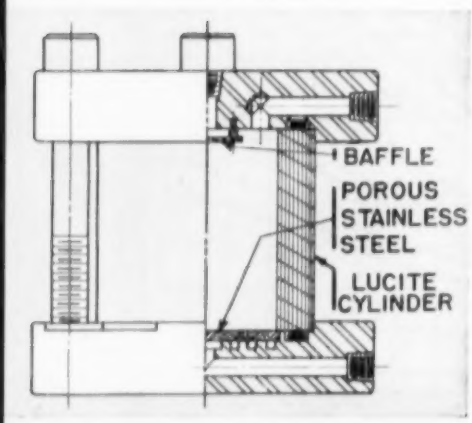
Early filtration theory (*1, 2, 3*) used the capillary analogy in attempting to describe fluid flow through filter cakes, but this approach proved inadequate and eventually was abandoned in favor of a new concept introduced by Kozeny (*4*). He demonstrated that flow through permeable beds may be expressed in terms of particle surfaces and that the bed may be considered as a single passage, the size of which (the mean hydraulic radius) corresponds to the volume and surface of the voids in the bed. Although Kozeny's original work was done in connection with permeability studies on water-bearing strata, his ideas were successfully applied to filtration by Carman (*5*).

The so-called Kozeny-Carman equation

$$u = \left(\frac{\epsilon^3}{(1-\epsilon)^2 k S_o^2}\right)\left(\frac{\Delta p g_c}{\mu L}\right) \qquad (1)$$

has been tested and verified by numerous investigators, but more recent work has shown that even this relation is inadequate in many studies. Grace (*6*) demonstrated some of the shortcomings in the Kozeny-Carman approach due to the compressibility and, hence, the changing porosity of most materials. He concluded that the Kozeny-Carman equation cannot be used effectively to predict the filtration resistance of cakes of compressible materials from data on the dry solids alone. This is particularly true in cases where flocculation occurs.

Fig. 2. Filter details.



Nevertheless, the Kozeny-Carman relation remains the best approach to date and is still being used as the basis for studies of many facets of the filtration problem (*7, 8*). Examination of Equation (1) quickly shows that ϵ, occurring as a cubic, is one of the most important factors involved. An actual evaluation of the so-called Kozeny function

$$\frac{\epsilon^3}{(1-\epsilon)^2} \qquad (2)$$

shows that its value decreases tenfold when the porosity is reduced from 0.78 to 0.57—a porosity decrease of only 27 per cent! Since porosity is such an important factor in the description of the filtration process, the changes in porosity likely to occur and the work done by other investigators in attempting to measure and use this factor in the description of the filtration process should be considered.

COMPRESSIBILITY

Incompressible cakes are those in which no significant change in ϵ occurs with increasing p_a. Compressible cakes, on the other hand, do show a porosity decrease with increasing p_a. This decrease may be due to one or more of several factors: (a) consolidation due to a rearrangement of particles into a more close-packed array; (b) consolidation due to floc breakdown—could be considered as included under (a) but not necessarily so; (c) consolidation due to deformation of particles, for example, the bending of acicular particles or the squeezing of soft particles; (d) consolidation due to the solution and consequent disappearance of part of the solids being removed by filtration; and (e) consolidation due to the actual crushing of hard particles in the cake. There may be factors other than the ones mentioned above, but these are probably the most common, listed more or less in the order of their importance

in cakes of materials of filtration interest.

Compressibility is a relative term and must be defined in order to have meaning. For example, even such a seemingly incompressible material as washed sand shows definite consolidation due to the crushing of the particles when some limiting pressure is exceeded. For purposes of this discussion, however, compressibility will be considered only in the 0 to 100 lb./sq.in. range.

Highly flocculated, finely divided materials may be deposited at the surface of the cake with a porosity as high as 0.98, although most materials start in the 0.7 to 0.9 range. Compression-permeability data have shown that ϵ may decrease as much as 0.5 units when the pressure on the solids, p_s, is increased from 0 to 100 lb./sq.in. Such a large porosity decrease, however, is unusual and is mentioned only to give some idea of an upper limit. Diatomaceous earth filter aids, on the other hand, show a porosity decrease of only a few hundredths of a unit and thus are generally considered incompressible. Most materials fall in the middle range with an ϵ variation of 0.1 to 0.2 units over the 0 to 100 lb./sq.in. range for p_s. In general, the higher the porosity upon deposition, the greater the compressibility, but this is not a hard and fast rule.

PREVIOUS WORK

Using the Kozeny-Carman equation as the basis for his calculations, Tiller (*7, 9*) succeeded in correlating data for a number of compressible materials by defining ϵ empirically for each cake as a function of pressure, thus:

$$\epsilon = \epsilon_o p_s^{-c} \qquad (3)$$

where

ϵ_o is the porosity at 1 lb./sq.in.,
p_s is the compressive pressure on the solids
c is an empirical constant

This power function is useful only with materials of moderate compressibility and in the pressure range 0.1 to 100 lb./sq.in. (*7, 10*). But when a filter cake is concerned, a knowledge of ϵ vs. p_s is not enough. We need to know how ϵ varies throughout the cake in order fully to describe the phenomena taking place. Young (*11*) made measurements on the water content of cakes of slime. He divided the cake into four sections and found that the layers nearest the septum were the driest and those farthest from the septum were the wettest. Rietema (*12*), using metal gauge pins within cakes of polyvinyl chloride, inferred the porosity distribution from electrical resistance measurements. He was able to demonstrate a phenomenon which he called "retarded packing compressibility." A theory was offered to explain the observed phenomena, which appeared to be electrical in nature.

Other attempts have been made to ascertain the structure of filter cakes, but none has been entirely successful. In addition, most of the measurements were indirect and thus possibly subject to some criticism on this account. But more important, the data found in the literature are not all in agree-

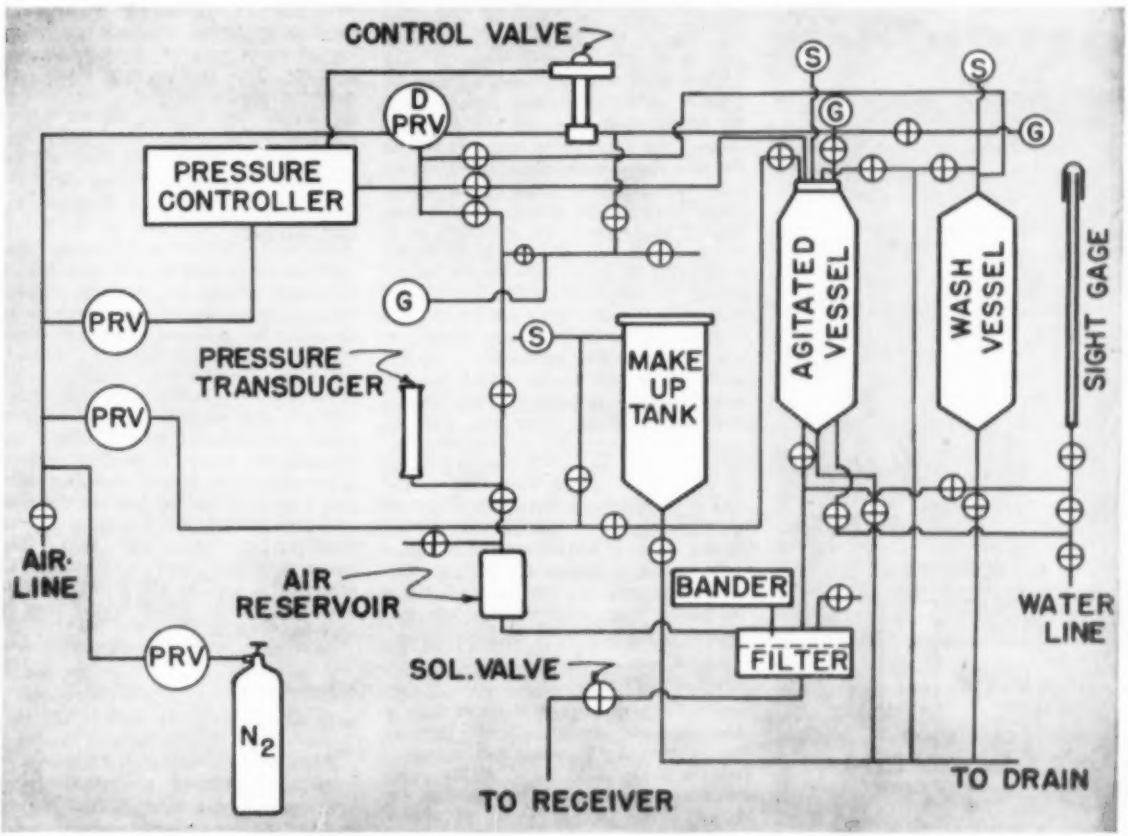


Fig. 1. Basic apparatus and equipment setup.

ment. Some of the data show ϵ decreasing most rapidly at the septum (*6, 13*), while others show the opposite (*7, 11*). That both extremes could be correct seems unlikely and, hence, this study was undertaken in an effort to obtain unequivocal data on the distribution of porosity in filter cakes of several materials of varying compressibility with the use of a direct measurement method.

Apparatus

The basic apparatus used was patterned after that of Carman (*14*) with many of the refinements suggested by Grace (*6*). The complexity of this apparatus is indicated in Figure 1.

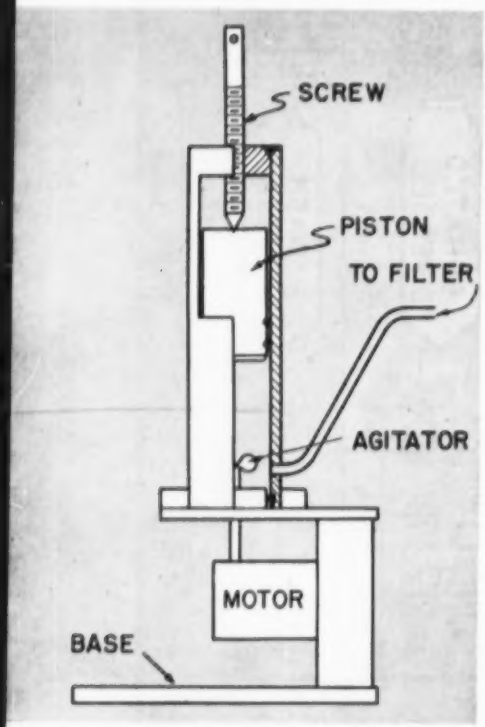


Fig. 3. Device for banding cakes.

BASIC APPARATUS

Fundamentally, this equipment was of the montejus type, built entirely of stainless steel and capable of withstanding several hundred pounds of pressure. The filter supply vessel contained a variable-speed agitator and had a capacity of 10 gal. The unagitated wash vessel had the same pressure rating, approximately the same capacity, and could be used for washing or permeability experiments. An even more important and less obvious use of the wash vessel is in the cleaning of the montejus. Pressurized water (100 lb./sq. in. or greater) from the wash vessel does a far better cleaning job on the montejus than does line water at perhaps 30 or 40 lb./sq. in.

MAKE-UP TANK

In a setup of this type, the problem of getting slurry into the montejus is a real one. The entry port is generally of necessity small, making a bucket-ladder operation tedious. This problem was solved by the construction of a 10-gal. make-up tank which was installed at floor level. With appropriate piping, the slurry was lifted directly to the montejus by means of air pressure. Air agitation was used in the slurry make-up tank.

FILTER

The filter was of the same basic design as that described by Grace (*6*) but with several important innovations. The salient feature of the filter was its simplicity (see Figure 2). The o-ring seals were easy to install and were found to hold without leakage at pressures as high as 1,000 lb./sq. in. Excessive tightening of the bolts was unnecessary, and for pressures of 100 lb./sq. in. or less, only two of the four bolts were used. Little or no information could be found on the tensile strength of Lucite tubing, thus it was decided to break a few cylinders on a hydraulic test setup in order to determine what pressure restrictions should be observed. Every cylinder (2 in. I.D. × 3 in. O.D.) tested successfully withstood 1,000 lb./sq.in. with no ill effects. Hence, it was concluded that in the 0 to 150 lb./sq. in. range the Lucite cylinders were more than satisfactory. Another important feature of this filter was that the entire filter cake could be observed, that is, none of the cake was hidden in a recess at the bottom of the filter. As in the Grace (*6*) filter, a bottom plate of porous stainless steel was used in conjunction with a circle of filter paper. His use of wire screen to support the porous stainless steel plate was not followed, but a sufficiently open drainage area was machined in the bottom of the filter instead.

INSTRUMENTATION

For the recording of filtration data, a four-point, two-second, 2.5 mv. recorder was employed. Pressure was measured with a 0 to 200 lb./sq. in. strain gauge pressure transducer. By varying the strain gauge voltage input, the transducer could be used for the 0 to 50 and 0 to 100 lb./sq. in. ranges (full scale) as well as for the nominal 0 to 200 lb./sq. in. range. Load beams were employed to measure filtrate weight. A 0 to 10 lb. beam and a combination 0 to 50, 0 to 100, and 0 to 150 lb. beam gave a wide range of filtrate capacity. The choice of range was governed by the flow rate expected and by the length of cycle desired. Appropriately sized, lightweight buckets with knife edges welded to the bottom side of the bail were used for collecting filtrate. The knife edge made possible the precise positioning of the bucket over the scribed mark on the load beam.

Copper-constantan thermocouples were used for measuring temperatures.

A pressure program controller, 0 to 25 per cent proportional, was used to supply pressure to the montejus. The equipment could be used for constant pressure, constant rate, or any other pressure program filtration. In the experiments described, constant rate was maintained as follows: a flowmeter was placed in the effluent line, the float position being sensed by a thermocap relay. The relay in turn activated the pressure program controller which was equipped with a continuous increase cam. When the rate dropped below the desired level, the thermocap relay activated the pressure controller which increased the pressure and, thus, the rate. When the rate returned to the desired level, the controller automatically stopped until the next pressure increment was called for. When properly adjusted, V vs. θ plots were almost perfectly linear.

As first set up, difficulty was experienced in achieving automatic control at low pressures with 100 lb./sq.in. supply pressure. This problem was taken care of by installing a differential regulator in the supply line so that the air supply was maintained at a constant differential above the pressure actually in the montejus.

CAKE BANDER

Cakes were banded with the use of the device (Figure 3). A slurry containing solids of a color which contrasted with the solids being filtered was placed in the slurry chamber of the bander. The piston was then inserted and the screw attached to the motor drive. When the motor drive was activated, small amounts of banding slurry were injected into the filter. By directing the stream of banding material down toward the face of the cake, there was practically no lag between the time of injection and the beginning of the deposition of the colored band. The bander has been used with success at pressures as high as 150 lb./sq. in. This device has been found useful also in applying precoats.

Experimental

APPROACH

In order to obtain data with a minimum of uncertainty, a direct observation method was used. Cakes having bands of contrasting colors were formed in the previously mentioned Lucite filter. By following the positions of the bands, changes in porosity were readily calculated.

To answer the question of what type of filtration experiment was to be used, the relative merits of constant pressure vs. constant rate filtration were weighed. The latter was chosen because the equal time intervals between equal weights of deposited cake solids made possible maximum precision in the application of bands and the reading of their positions. In addition, errors due to unequal settling in the filter and in the feed lines were minimized by having a constant rate of slurry flow to the filter. At first

the band positions were read by eye and recorded; this was found to be an impossible procedure when there were as many as 20 bands to be read in a period of 30 sec. This problem was solved by photographing the filter every time a set of readings was desired and then examining the developed negatives at a later date. On page 328 is a typical photograph of a cake banded at equal solids intervals during a constant-rate filtration.

PROCEDURE

The equipment was set up as shown in Figure 1. A 1% slurry was prepared in the make-up tank and transferred to the montejus. The cake bander was filled with 2% banding slurry, and all the lines and the filter filled with water. Instruments were zeroed, the filtrate outlet was leveled with the liquid level in the montejus, and pressure was applied. The filtration rate was manually controlled up to about 5 lb./sq.in., at which point the automatic rate control was allowed to take over and complete the run. Bands were applied at regular time intervals by an automatic timer and pictures of the filter were taken simultaneously with the application of banding slurry. The recorder made a record of filtrate volume (wt.), pressure, and temperature—all vs. time.

Discussion

Constant-rate filtration runs were carried out with flux-calcined diatomite, calcium silicate (gyrolite), wood pulp, and perlite. The consolidation process has been vividly demonstrated by means of time-lapse movie techniques.

Figures 4 and 5 show cake band positions plotted vs. time for typical runs on diatomite and wood pulp. Since the bands were applied at constant intervals of solids, the decrease in porosity may readily be observed. In all cases the same porosity distribution is presented to the liquid face, as evidenced by the parallel nature of the diagonal lines connecting points in analogous positions to the face. Throughout both runs (and all other runs made) this condition prevailed. (Although such a situation was assumed by Carman (*13*), this constitutes the first positive proof of this phenomenon known to the author.) Further inspection of Figures 4 and 5 reveals important differences between the two materials in question. The roughly horizontal lines follow locations of individual bands within the cakes. In both the diatomite and the wood pulp, the lines slope downward to the right, indicating consolidation. Shrinking of each layer is evidenced by convergence of these lines. The diatomite lines are almost perfectly straight while the wood pulp lines show a definite increased upward curvature near the surface of the cake. This probably indicates that the wood pulp slurry was slightly flocculated and the extra curvature near the face of the cake traces floc breakdown. Figure 6 shows the V-θ-Δp plots for the two runs being discussed. The almost incompressible diatomite has a linear pressure increase while the wood pulp Δp vs. θ plot has definite curvature. This points up the greater order of magnitude of compressibility for the wood pulp.

Again, in Figures 4 and 5, the pressures given at the bottom of the graphs correspond to the Δp values at the points given. If we assume zero (or negligible) septum resistance and thus zero pressure drop across the septum, then the Δp values given correspond to the pressure stress on the solids (p_s) which are next to the septum ($\Delta p = p_s$, $p_s = 0$). Since the diagonal



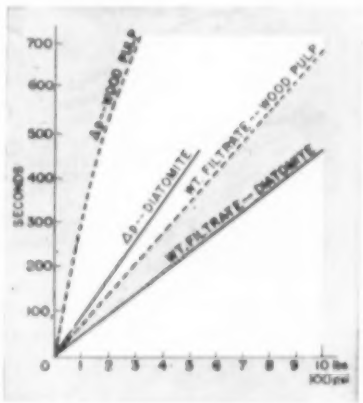


Fig. 6. V-θ-Δp plots for wood pulp and diatomite.

lines trace equal porosity and porosity is directly related to p_s, the diagonal lines should also trace equal p_s. Thus, this method could be used for determining the distribution of pressures through filter cakes.

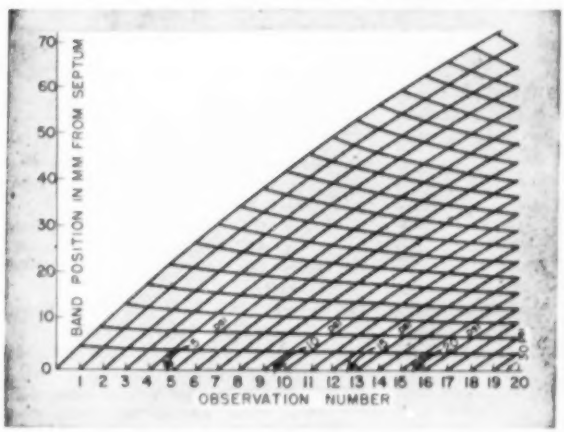
Tiller (*7*), using a consolidometer, related ϵ to p_s with cakes of kaolin. Then, with the Kozeny relationship,

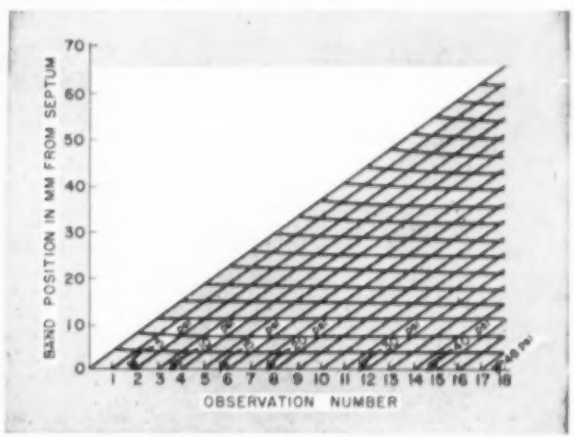
$$\int_{p_a}^{p} \frac{\epsilon^3}{(1-\epsilon)^2}\, dp_a \qquad (4)$$

he calculated p_s vs. X/L values. By combining his plots, it was possible to obtain ϵ vs. X/L relationships for comparison with similar data.

Young (*11*) sectioned filter cakes of slime and determined cake specific gravity and water content as functions of the distance from the filter septum. These data were used in calculating ϵ vs. X/L data for comparison with

Figs. 4 and 5. Cake band positions vs. time for typical runs on wood pulp (left) and diatomite (right).





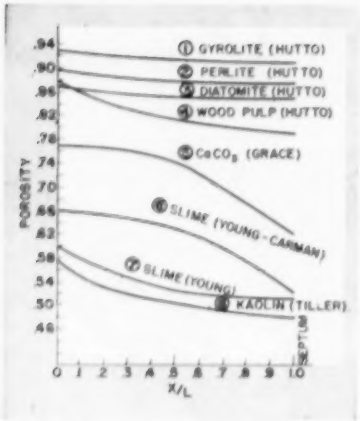


Fig. 7. Comparative porosity data for various materials.

data mentioned above. Similar data were taken from Young's (*11*) paper by Carman (*13*) for illustrative purposes. Grace (*6*) gave data relating ϵ to X/L for calcium carbonate.

Figure 7 compares the above-mentioned information with data obtained by the author on various materials. With the exception of curves 5 and 6, all the data follow the same general pattern. There is a relatively rapid decrease in ϵ near the surface, followed by an almost linear, less rapid decrease continuing to the septum. The question immediately arises as to whether all of the data are valid or whether one group or the other is in error. Curve 5 on calcium carbonate was given by Grace (*6*) with very little explanation. He said merely that the data were obtained by direct measurement of sectioned cakes. The data may be reliable, but the evidence presented is inadequate. Curve 6, drawn by Carman (*13*) from data by Young (*11*), may be discounted since Young's data were not specific as to the *exact* portion of the cake represented by the figures and, furthermore, there were only three points to go by. Other more specific data on the same slime by Young show the opposite type of curve.

Hence, none of the conflicting data have been found to be a serious challenge to the data submitted by the author. Furthermore, curves 7 and 8 concur. Tiller's curve 8 is especially important as it represents a semitheoretical approach to the problem.

This discrediting of conflicting data does not necessarily mean that the opposite type of curve could not exist, but it does seem unlikely. One possible exception might be the case where a cake of difficultly filtered material became almost impermeable. Then, if more slurry were in contact with the cake and the cake were oriented so that solids could continue to deposit by *sedimentation*, a section of almost uniform porosity might be deposited. While such a situation might produce this odd cake, it could not legitimately be called a *filter* cake.

A general statement may be made that the porosity in a filter cake decreases relatively rapidly near the liquid-solid interface and then at a less rapid, almost linear rate continuing to the septum. It has been suggested that there is a large discontinuity right at the septum itself, but the investigation was not designed to deal with this aspect of the problem.

Attention should be called to the paper by Heertjes and Haas (*15*) in which the initial phases of cake formation were discussed. It was found that, depending upon prefilt concentration, the nature of the solids in the prefilt, and the nature of the filter septum, either of two types of filtration could take place—"blocking filtration," when individual particles block individual holes in the septum; and "cake filtration," when solid particles bridge over the holes in the septum producing a minimum of filtration resistance at the septum.

CLARITY

From the statements previously made concerning the diagonal lines of equal p_s in Figures 4 and 5, it is evident that in a constant rate filtration where Δp is constantly increasing, the entire cake is undergoing a continuous consolidation. Neglecting septum resistance, the layer adjacent to the septum is continually changing with ϵ corresponding to the full Δp. On the other hand, in constant pressure filtration the layer next to the septum remains essentially unchanged from the time that full pressure is reached until the end of the run. Clarity is undoubtedly affected by rearrangements within the cake and certainly by changes in the part of the cake adjacent to the septum. Therefore, it seems likely that with all other conditions the same, clarities should be better in a constant-pressure filtration than in a corresponding constant-rate filtration. This is pure conjecture, however, and no work has been done to test the idea.

REVERSIBILITY OF CAKE CONSOLIDATION

Other authors (*7*, *13*) have mentioned the apparent irreversibility of cake consolidation. As a check on this phenomenon, several cakes were carefully removed from the filter by extrusion with a plunger, dried, and the band positions measured for comparison with the ordinary photographic record. Although the measurements on the dried cake were less precise than might have been desired, there appeared to be a definite expansion taking place with the removal of pressure. This amounted to 1 or 2% in most cases; cakes of higher porosity generally expanded more than cakes of low porosity. Other information obtained in the author's laboratory with a rotary precoat filter indicates that with a 2-in. precoat of diatomite, there is 0.015 to 0.020 in. shrinkage when the surface of the cake is sealed with a difficultly filtered material. A 2-in. cake of lighter density perlite generally shrinks at least twice the above amount.

Notation

ϵ = porosity, void fraction
ϵ_o = constant in Equation (3)
v = superficial flow velocity
k = constant in Kozeny's equation (usually 5 ± 10 per cent)
S_o = specific surface of solids
Δp = total pressure drop across filter
g_c = conversion factor from lb.m to lb.f
μ = viscosity
L = cake thickness
p_s = compressive pressure on solids in cake
p_a = liquid pressure in cake at x distance from liquid face
c = constant in Equation (3)

Presented at A.I.Ch.E. meeting, Boston, Massachusetts.

Literature Cited

1. D'Arcy, H. P. G., "Les Fontaines Publiques de la Ville de Dijon," Victor Dalmont, Paris (1856).
2. Seelheim, *Z. Anal. Chem.*, **19**, 387 ff. (1880).
3. Slichter, C., *19th Ann. Rep., U. S. Geol. Survey*, **II**, 295ff. (1897-98).
4. Kozeny, J., *Wasserkraft und Wasserwirtschaft*, **22**, 67-70, 86-88 (1927).
5. Carman, P. C., *Trans. Inst. Chem. Engrs.* (London), **15**, 150-166 (1937).
6. Grace, H. P., *Chem. Eng. Progr.*, **49**, 303-318, 367-377 (1953).
7. Tiller, F. M., *Chem. Eng. Progr.*, **49**, 467-479 (1953).
8. Ingmanson, W. L., *Chem. Eng. Progr.*, **49**, 577-584 (1953).
9. Tiller, F. M., *Chem. Eng. Progr.*, **51**, 282-290 (1955).
10. Terzaghi, K., and R. B. Peck, "Soil Mechanics in Engineering Practice," John Wiley, New York (1948).
11. Young, G. J., *Trans. Am. Inst. Mining Eng.*, **42**, 752-784 (1911).
12. Rietema, K., *Chem. Eng. Sci.*, **2**, 88-94 (1953).
13. Carman, P. C., *Trans. Inst. Chem. Engrs.* (London), **16**, 168-188 (1938).
14. Carman, P. C., *J. Soc. Chem. Ind.*, **53**, 159T-165T (1934).
15. Heertjes, P. M., and H. v. d. Haas, *Rec. Trav. Chim.*, **68**, 361-383 (1949).

COMPUTERS IN MANAGEMENT COST ACCOUNTING

The actual running-time for a computer-solved problem may be only a matter of hours, compared with months of manual calculating effort required to develop significant data for management decisions. The authors believe that such computer applications are necessary to deal with the complexities of today's large chemical plants and the even greater ones to be expected in the future.

R. L. Hershey and C. R. Schwartz

E. I. DuPont de Nemours & Company, Wilmington, Delaware

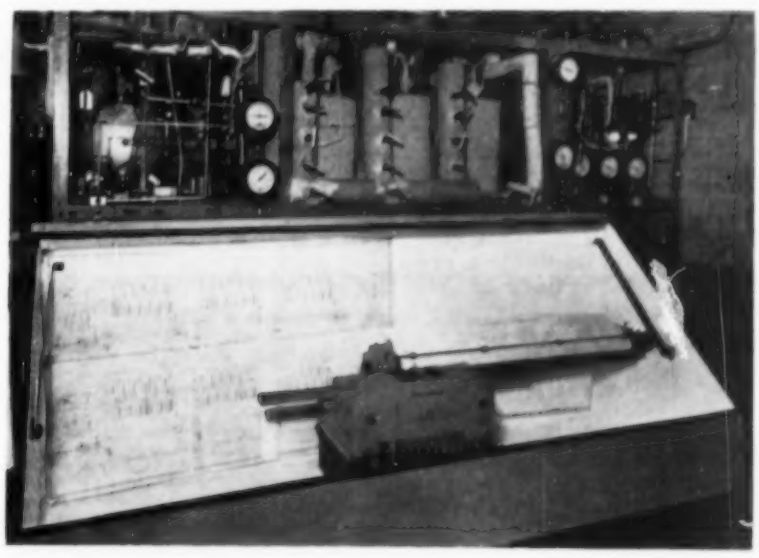
Any imaginative manager will see in the modern electronic-computing and data-processing machinery something of enormous potential significance to his operating techniques. In this article, a brief look is given to a specific analytical cost accounting calculation which was put on an electronic computer successfully in the course of a series of experimental studies of a variety of computer problems. This particular calculation, when applied completely to one of the large complex multiproduct plants, is so time consuming when done by the use of desk calculators that it can only occasionally, say once a year, be carried through. The data used must represent average figures over a relatively long time. Results are similarly limited to representing averages over a period of time well past when they are finally obtained. Despite these shortcomings, for many years this calculation has been judged worth making from time to time because of the many uses that are made of the results. The calculation is, perhaps, mainly of interest here because it is typical of others which might have achieved significance as regular operating tools if it had not been true in the past that the results were either too stale when obtained or else simply unobtainable.

This particular problem was also a real challenge in computer programming and techniques, and was indeed a challenge to the mechanical stamina

Table 1.—Plant Cost Sheet—Manufacturing

Product A

Cost item	Units	Quantity	M $	Unit Cost $
Raw material—1	M ton	1,638	19,770	
By-product (Cr.)	M gal.	34,784	(8,194)	
Water	MM gal.	4,200	42	
Steam	MM lb.	449	238	
Electricity	M kw.-hr.	16,400	82	
Operating salaries	M hr.	107	384	
Operating wages	M hr.	1,074	2,716	
Maint. wages	M hr.	124	308	
Maint. materials			240	
Operating overhead			1,397	
Maint. overhead			296	
Control laboratory	M hr.	1	12	
Technical expense			3	
Prop. taxes & ins.			76	
Depreciation	M $ inv.	22,500	1,912	
Cost	M ton	1,020	$19,282	19.00/ton



Readout typewriter of Fischer & Porter automatic data logging system installed in pilot plant of an oil refinery.

Table 2.—Plant Cost Sheet—Manufacturing

Product B

Cost item	Units	Quantity	M $	Unit Cost $
Product A	M ton	620	11,780	19.00/ton
Raw material—II	M lb.	3,240	100	
—III	M lb.	600	305	
Water	MM gal.	45,250	490	
Steam	MM lb.	8,000	4,242	
Electricity	M kw.-hr.	1,500,000	7,492	
Operating salaries	M hr.	242	852	
Operating wages	M hr.	1,708	4,497	
Maint. wages	M hr.	735	1,832	
Maint. materials			836	
Operating overhead			2,515	
Maint. overhead			1,754	
Control laboratory	M hr.	15	129	
Technical expense			565	
Prop. taxes & ins.			270	
Depreciation	M $ inv.	44,500	3,779	
Cost	M ton	400	$41,438	104.00/ton

Table 3.—Plant Cost Sheet—Manufacturing

Product C

Cost item	Units	Quantity	M $	Unit Cost $
Product B	M ton	110	11,392	104.00/ton
Water	MM gal.	16,800	175	
Steam	MM lb.	1,864	988	
Electricity	M kw.-hr.	50,400	252	
Operating salaries	M hr.	33	117	
Operating wages	M hr.	372	1,044	
Maint. wages	M hr.	154	384	
Maint. materials			151	
Operating overhead			522	
Maint. overhead			377	
Control laboratory	M hr.			
Technical expense			19	
Prop. taxes & ins.			63	
Depreciation	M $ inv.	10,100	850	
Cost	M ton	169	$16,334	97.00/ton

Table 4.—Plant Cost Sheet—Manufacturing

Product X

Cost item	Units	Quantity	M $	Unit Cost $
Product C	M ton	92	8,891	97.00/ton
Raw material—IV	M lb.	200	8	
Steam	MM lb.	54	29	
Electricity	M kw.-hr.	1,000	5	
Operating salaries	M hr.	12	41	
Operating wages	M hr.	84	211	
Maint. wages	M hr.	12	29	
Maint. materials			12	
Operating overhead			105	
Maint. overhead			27	
Control laboratory	M hr.	3	26	
Technical expense			12	
Prop. taxes & ins.			5	
Depreciation	M $ inv.	1,500	128	
Cost	M ton	88	$9,529	108.00/ton

Table 5.—Proportion Factors for Product X Roll-up

	Product A to Product B		Product B to Product C		Product C to Product X		Proportion factors
Product A	620 / 1,020	×	110 / 400	×	92 / 169	=	
	.6078	×	.2750	×	.5444	=	.0913
Product B			.2750	×	.5444	=	.1497
Product C					.5444	=	.5444
Product X							1.0000

of the computer itself. Hence, the successful solution was a considerable technical achievement. The significance of that success lies, however, not in this accomplishment in computer technique per se, nor even in the greater usefulness that the calculation itself has when done at computer speeds (though that benefit is real), but in the implications for the future, when, it is hoped, new systems of management communication, carrying data of vastly improved relevance and significance, may become available.

Despite these pleasing prospects, unfortunately the conclusion was inevitable that computers will be no panacea for all management woes. Many managers are often tempted to think that all would be well if only they could get the right people in the right jobs. Personnel selection is certainly a large management responsibility in which computers will not be of much help. Questions of organization and of broad policy—which business to enter or to avoid, when and by how much to expand those one is already in, how to apportion total technical effort between the research, the manufacturing, and the marketing programs—all these, and many more, are typical of critical management questions to which only the judgment of human beings can provide sound answers.

Multiple Uses of Computers

But if computers can't make policy, there still remain many opportunities for their use in every-day operations. In the matter of broad management problems computers can be of inestimable value. One such problem could perhaps be phrased in this way: how can a company, in every phase of its operation, first, set for itself high performance standards; second, adjust those standards constantly to changing conditions; third, compare regularly its current performance with those standards promptly enough to detect and act on any significant deviations? To this series of questions, management would like meaningful answers because they would supply all management levels with significant and current measures of efficiency and, perhaps more important, would indicate the specific areas needing attention.

The building of an informational structure to supply these answers fully in a chemical business of any complexity is no easy matter. But approaches can be visualized and the availability of high-speed computers prevents one from being frightened off by the sheer magnitude of the figure-handling problem.

One can examine a possible scheme for obtaining the answers to the above questions in the area of factory cost for a chemical product by considering just the item of ingredient cost. In any given operating period, the figure for this cost on the cost sheet will be dependent on the unit cost of ingredients, the chemical yield, and perhaps on the volume of production. (Other cost items will usually be more volume sensitive than this one.) To set a sound standard, a figure for a good yield performance or, if it is really volume sensitive, a series of figures relating volume and yield will be needed. A standard-ingredients-cost figure for a fixed period at a known volume is obtainable then from the appropriate standard yield and the current unit ingredient cost.

Provision must be made for adjusting the standard, for changes in unit ingredient cost, and less frequently probably for changes in yield because of technological improvement.

Finally, if prompt comparison is provided, say monthly, of actual ingredient cost against the properly adjusted standard, a measure is obtained of the efficiency of ingredient use and an indication of whether corrective action is required or not. (Of course, direct process measurements may have given an earlier indication of yield departure from standard—and then again they may not.)

Applied to a single item of cost for a single product, all this sounds ridiculously simple. But the complexities mount when every item of cost for a variety of products, some of which will have many subvarieties, needs to be handled. Of course, the basic setting of standards is essentially a one-time job needing revision only as process improvement is realized. Adjustments for changes in such factors as wage rates, costs of purchased materials, and production volume need more constant attention. But the real problem, of course, is to prepare the actual costs, adjust the standards for actual conditions, make item-by-item comparisons, and identify the critical areas, if any, sometime before the whole matter has only historical interest. For operations such as those at Du Pont the only hope of using such a scheme lies in high-speed data processing.

A Cost "Roll-up" Problem

In the course of experiments, DuPont tried on a high-speed computer the solution of a "cost roll-up" problem. The "cost roll-up" is a device used by the company over the years for many analytical cost studies. It has already been noted that in the past the time required for the calculation places certain limitations on the usefulness of the figures.

The problem arises in those cases where it is desired, in a large integrated operation, to reduce the costs of a product to its fundamental elements of purchased ingredients, power, and labor.

An example is the plant at Belle, West Virginia, where from a basic synthesis gas operation a variety of gases and gas mixtures (nitrogen-hydrogen, carbon monoxide-hydrogen, hydrogen, carbon monoxide) is manufactured, these gases being converted to such products as ammonia

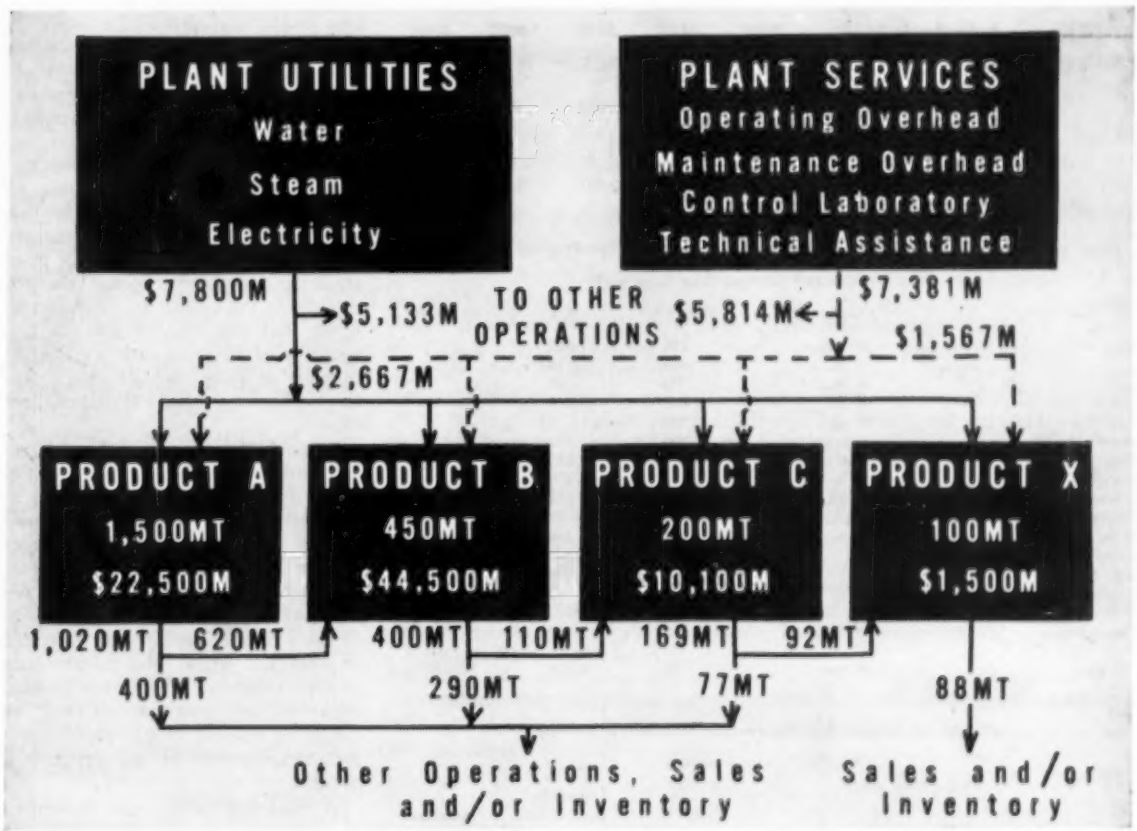


Fig. 1. Accounting flow sheet (annual basis), product "X."

and methanol. Some ammonia is reacted further with carbon dioxide to make urea, and some methanol is processed on to ethylene glycol. In all, fifty-seven end products are manufactured at this plant involving in turn nearly 100 processing steps. (In addition at this plant there are several hundred nonchemical operations such as steam, generated electricity, and other utilities, packaging operations, and service facilities such as the hospital, cafeteria, quality control laboratory, and accounting force.) If then the company wishes to know the cost of a product at the end of this complex train in the terms mentioned, it has a formidable problem of following costs.

The accompanying tables illustrate the application of the "roll-up" techniques to a typical complex chemical manufacturing process. Although an actual cost system includes the costs of product distribution, selling, and research and development, the tables indicate only the "roll-up" of manufacturing costs.

Explaining "Roll-up" Technique

Figure 1 is an accounting flow sheet covering manufacture of product X by a process involving manufacture of the three intermediate products A, B, and C. Manufacture of each of these four products consumes a portion of the total plant supply of utilities and requires a portion of available plant services. Production of intermediate product A amounts to 1,020M tons a year, of which 620,000 is consumed in manufacture of intermediate product B and 400,000 is either sold or consumed elsewhere on the plant. Production of intermediate product B is 400,000 tons, of which 110,000 tons is consumed in intermediate product C and 290,000 tons is for sale or consumption elsewhere. Production of intermediate product C is 169,000 tons, of which 92,000 tons is consumed in manufacture of product X and 77,000 tons is for sale or consumption elsewhere. Finally, production of the product X, the cost of which is to be analyzed by "roll-up," is 88,000 tons a year, all of which is for sale.

As noted in the following tables, conventional process cost accounting will supply the unit cost of each of the four products shown here. However, conventional process cost accounting will not give the detail of cost of product X (by primary cost elements) that is required for management guidance.

A conventional process accounting-cost sheet for product A (Table 1) shows consumption and cost of raw materials used and also the cost of utilities, salaries and wages, plant services, and fixed expense charged directly to the operation. It should be noted that the cost of salaries and wages used in producing utilities, or in plant services such as the laboratory, is buried in the total cost of these items.

In Table 2 a conventional cost sheet for product B is shown. The quantity of product A consumed is valued at the unit cost, \$19.00/ton, determined on the product A cost sheet. Other items entering directly into this process, such as operating wages, are detailed as in product A cost sheet.

Table 3 is a similar cost sheet for product C. Again, the intermediate product consumed is valued at its total unit cost, and other entries, such as operating wages, reflect only the cost incurred directly in the product C process.

A conventional process accounting cost sheet for product X is shown in Table 4. Total cost of this product is determined to be \$108 a ton. The process cost sheet shows the cost of operating wages for the product X process, but labor costs incurred in other operations are buried. Likewise, other primary cost elements, such as utilities and plant services, are buried in the costs of product C. The effect of a wage rate increase could not be determined, for example, on the cost of product X from the data given by conventional costing. It is necessary to break the \$108 a ton cost down into its primary cost elements.

The first step in a "roll-up," the calculation of "proportion" factors (Table 5), tells what part of the total production of products A, B, and C is

Table 6.—Partial Roll-up of Product X Costs

		Prod. A	Prod. B	Prod. C	Prod. X	
Proportion factor		.0913	.1497	.5444	1.0000	total
Cost items	units	M $	M $	M $	M $	M $
Operating wages	M hr.	248	673	568	211	1,700
Cost	M ton	1,761	4,439	2,691	638	9,529

Table 7.—Partial Roll-up—Manufacturing Only for Product X

Plant Utilities and Services (Not Rolled-up)

Cost items	Units	Quantity	M $	Unit Cost $
Raw material—I	M ton	150	1,805	
—II	M lb.	485	15	
—III	M lb.	90	46	
—IV	M lb.	200	8	
By-product (Cr.)	M gal.	3,176	(748)	
Water	MM gal.	16,300	172	
Steam	MM lb.	2,320	1,225	
Electricity	M kw.-hr.	254,212	1,270	
Operating salaries	M hr.	77	268	
Operating wages	M hr.	641	1,700	
Maint. wages	M hr.	217	540	
Maint. materials			243	
Op. & maint. OH			1,414	
Control laboratory	M hr.	5	47	
Technical expense			106	
Depreciation	M $ inv.	15,690	1,418	
Cost	M ton	88	9,529	108.00/ton

Table 8.—Proportion Factors for Product X Roll-up

Plant utilities and services

	unit	Total production	Used in manufacture of product X	Proportion factor
Utilities:				
Water	MM gal.	80,500	16,300	.2025
Steam	MM lb.	10,400	2,320	.2231
Electric	M kw.-hr.	1,568,000	254,212	.1621
Services:	$	7,381	1,567	.2123

finally consumed in manufacture of product *X*. As shown in Figure 1, 620,000 tons of product *A*, out of a total production of 1,020,000 tons, was consumed in product *B*. This gives a factor of .6078. Likewise, factors for consumption of product *B* in product *C*, and of product *C* in product *X* are set. After the factors are multiplied, the proportions of total production of *A*, *B*, and *C* that were consumed in product *X* are fixed.

The proportion factors thus developed are applied to the dollars of direct cost elements shown on the process cost sheets for products *A*, *B*, and *C*. Table 6 illustrates the calculation for one element of direct cost, operating wages. Although the product *X* costs include $211,000 for direct operating wages, there is a "rolled-up" operating wage cost of $1,700,000 dollars when the proper share of operating wages incurred in making products *A*, *B*, and *C* is included.

The partial "roll-up" of cost after the cost of manufacture for products *A*, *B*, and *C* thus has been broken into primary cost elements (Table 7). This partial roll-up shows the total cost of raw materials, utilities, and services that roll into product *X* through prior manufacturing operations. However, such items as utilities and plant services, are not yet broken down to primary elements. This breakdown is the next step in the "roll-up."

In Table 8 the calculation of proportion factors, similar to the ones calculated for manufacturing operations covering plant utilities and services, is illustrated. Factors for utilities, which can be measured in terms of physical quantity, are based on the total quantities produced related to the quantities that roll into product *X* through manufacturing operations. The factor for plant services is based on total dollars of services costs related to dollars charged to product *X* through manufacturing operations.

These factors then can be applied to utilities and services cost (for which process cost sheets are also prepared in the course of plant costing). The results of the final "roll-up" of total dollars is shown in Table 9. Here the total cost of product *X* is broken down into its primary elements, raw materials, purchased power, salaries and wages, maintenance materials, and fixed expenses. Data shown in this table are repeated in a more readily usable form in Table 10, with costs reduced to dollars a ton of product *X*. From this unit-cost roll-up one can note in Table 10 that, of the total cost of $108 a ton, operating wages at $25.50 a ton are the largest single element in cost and raw material I at $20.52 a ton is second.

Table 9.—Total Rolled-up Cost for Product X
(Quantity and Dollars)

Cost item	Units	Quantity	M $	Unit Cost $
Raw material—I	M ton	150	1,805	
—II	M lb.	485	15	
—III	M lb.	90	46	
—IV	M lb.	200	8	
—V	M ton	61	687	
By-product (Cr.)	M gal.	3,176	(748)	
Electricity-purch.	M kw.-hr.	281,439	1,128	
Operating salaries	M hr.	287	1,007	
Operating wages	M hr.	858	2,244	
Maint. wages	M hr.	423	1,052	
Maint. materials			505	
Prop. taxes & ins.			134	
Depreciation	M $ inv.	19,395	1,646	
Cost	M ton	88	9,529	108.00/ton

With unit cost and quantity data thus "rolled-up," it is possible to ascertain promptly the effect of a plant-wide increase in wage rates on cost of product *X* although perhaps the majority of the labor involved is employed in areas outside the product *X* plant itself.

"Roll-up" of plant investment in the same way as "roll-up" of cost is the only technique DuPont has found that will show how various segments of investment in a complex plant may properly be charged to products. It also serves as an indication of how the investment is being utilized and spotlights reasons for failing to utilize it fully.

Of course, it is clear that the "roll-up" of cost of all products made in a complex plant is a time-consuming process if men with desk calculators are used for the job. However, the "roll-up" of cost and investment has been so useful that for many years DuPont has considered that the spending of as many as 1,000 man-hours for a "roll-up" of a single plant was in order. Because of the time involved, DuPont seldom felt justified in making more than one such "roll-up" a year. On the computer this same "roll-up" is now performed and completed statements printed in four hours. Adapting the job to the computer, however, is a major undertaking. Fourteen months of full-time effort by two "programmers" were required to perfect the job.

The use of computers in management work may never guarantee business success, but at least in large operations successful businesses in the future will find the use of computers essential. In quasimathematical terms, they will be a necessary, if not a sufficient, condition.

Presented at A.I.Ch.E. meeting, White Sulphur Springs, West Virginia.

Table 10.—Total Rolled-up Cost

Product X Unit Factors

Cost elements	Units	Quantity /ton	Unit price $	Cost /ton $
Raw material—I	ton	1.70	12.07	20.52
—II	lb.	5.51	.03	.17
—III	lb.	1.02	.51	.52
—IV	lb.	2.27	.04	.09
—V	ton	.69	11.26	7.77
By-product (Cr.)	gal.	36.09	.24	(8.77)
Electricity-purch.	kw.-hr.	3,198.00	.004	12.82
Operating salaries	M hr.	3.26	3.51	11.44
Operating wages	M hr.	9.75	2.61	25.50
Maint. wages	M hr.	4.81	2.49	11.98
Maint. materials				5.74
Prop. taxes & ins.				1.52
Depreciation	$ inv.	220.39	8.5%	18.70
Cost				108.00

Note: In all these tables M means thousands; MM—millions; T—tons.

A solid foundation as input medium for commercial computer applications:

INTEGRATED DATA PROCESSING

IDP (Integrated Data Processing) is an accepted method of modern business communication wherein business data, once introduced into the system, need not be recopied. Described here are techniques and equipment commonly associated with IDP and their application to a system in which all documents directly relating to sales order, shipping, and billing are semi-automatically prepared and statistical data for sales and inventory reporting are produced effortlessly as by-products.

William A. Crichley | Diamond Alkali Company, Cleveland, Ohio

Many companies with far-flung operations are organized on a divisional pattern based on major product groups with centralized staffs controlling and scheduling the day-to-day operations.

Present-day thinking about multi-plant operations utilizing complex distribution plans, poses a tremendous challenge in so far as the accurate, rapid accumulation and reporting of current business data are concerned. That is why office automation, once considered a possibility for tomorrow, is regarded increasingly as a necessity today.

Business data must be accumulated with greater speed and accuracy if such information is to continue contributing effectively to short-range planning and problems. Division Management is often placed at an economic disadvantage in being forced to wait five weeks or longer to discover the relative profitability of the previous month's efforts. Historic data continue to hold importance, of course; but more periodic or frequent reporting enables corrective action of significant value. Accordingly, all data accumulation and processing should be brought closer into line with current operations to promote more efficient management employing scientific techniques.

Significantly, Richard G. Canning (*1*) emphasized the importance of input methods, believing that such methods remain the greatest unsolved problem facing systems engineers.

Characteristics of Detailed Data

Diversified influences upon business operations preclude application of a common approach to a standard type of problem. In time, operations research may well answer many of these needs. But today, business data must be maintained in complete, simple detail to enable its build-up, or classifying, on most any basis called for.

Three characteristics of detailed business data should be stressed:

1. **In contrast to summarized figures, detailed data are voluminous.**

2. **The detail is less than 100 per cent valid. Even though extensive postchecking systems can be instituted, the most effective quality control remains at the point of origin. Rechecking is best done at the lowest level. Also, each clerical rehandling of an item of information invites the possibility of further error.**

3. **The value of currentness is significant. Yesterday's sales are most meaningful today; each passing day progressively diminishes the usefulness of a business fact; hence, prompt collection of data from dispersed plants and offices provides a real challenge—and opportunity—to modern systems engineers.**

Selection of Integrated-Data-Processing Program

In 1953 Diamond Alkali asked the Special Services Section of its public accountants, to make a paperwork survey throughout the organization. The company had experienced the sudden impact of "mushroom paperwork" and desperately sought relief. The systems audit pointed to further mechani-

zation possibilities in several clerical areas.

Extension of tabulating applications, installation of an integrated-data-processing system, and immediate planning for subsequent utilization of electronics were accordingly recommended. The systems and procedures staff could undertake the first step simultaneously with one of the other two.

From a control standpoint, it was believed that integrated-data processing—or IDP, as it is called—and electronic data processing—EDP—were interdependent; only through engineering one composite system could the pressing problems of time, speed, and accuracy be adequately answered.

After a survey of existing processing equipment, it was quickly determined that compatibility, though not completely adequate, posed no impassable barriers. Integration systems were just picking up momentum back in early 1954; but few were doing the complete from start-to-finish job which was believed essential performance in any IDP system. Electronic processing was heralded as the "cure-all" for commercial paper work processing. After considerable debate, it was decided to proceed with an IDP program for four major reasons:

1. **The sales order-invoicing system was not providing the customer service desired.**
2. **It was possible to proceed relatively faster in IDP than in EDP; this permitted time for extended mechanization through tabulating and enjoyment of the benefits in the interim period.**
3. **Chronologically, a communication system providing input must precede computer processing.**
4. **IDP was presented as an economically sound program.**

What is IDP and how can it effectively benefit modern office work operations?

CONVENTIONAL IDP EQUIPMENT

Integrated-data processing is a business data system into which data, once introduced, need not be recopied. Nearly 80 per cent of common sales-order information is reused in related plant order, bill of lading, invoicing, and statistical reporting. Elimination of repetitive-data reproduction has high time-saving potential, particularly when the checking time and its attendant error possibility are eliminated.

A class of business machines has been specifically designed to self-perpetuate the data once these are introduced into the IDP system. Although there is a variety of equipment available, units in widest usage at present are produced by Western Union, American Telephone and Telegraph, and Commercial Controls.

The importance of simultaneously communicating and processing—an "on-line" operation, as it is termed—varies with the particular application involved. If the processor cannot serve on-line as well as off-line, additional equipment is necessary in small installations using but one processing machine. For example, a sales office needs to participate in message communication as well as data processing; therefore, if the volume of work permits, a dual-purpose machine can serve both requirements adequately.

SPECIALIZED INTEGRATION EQUIPMENT

In addition to the typewriter keyboard machines cited, various adding, calculating, bookkeeping, and special-purpose IDP machines are currently marketed. Basically, each provides an output tape in conjunction with the processing. Such specialized equipment for air reservations instantaneously communicate with a centralized computer to check and reserve travel space. This is one of the best examples of commercial IDP-EDP applications to date.

As an alternate for punched-paper tape, the processing system designed by Commercial Controls also provides a marginally punched card. At Diamond cards are preferred to roll tape; they are easier to fold and file. Fan-fold tape is extensively used in the IDP system. Another "storage" ve-

Diamond Alkali IDP system now "on-stream" embraces 18 plants and 10 sales offices.



ADVANTAGES OF IDP

Business data—voluminous, difficult to control, and (like a newspaper)—quick to age—must be accumulated with increased speed and accuracy to meet today's operating and competitive conditions and to be geared to meet tomorrow's even greater needs.

- IDP permits an item of data to be entered once,—eliminates recopying as the data are self-perpetuated.
- Flexibility of data introduction—data may be introduced by the operator, by master tape, or by both.
- Data may be selectively punched out into one or more tapes.
- A variety of both conventional and special-purpose IDP equipment is available today.
- Checking is best done at point of origin.
- IDP promotes continuous work-flow.
- The fact that data can be automatically converted from one machine language to another offers greatest economic savings.
- IDP can be operated "on-line" to a central computer.

hicle is recording-disc storage, which is currently under experimentation. This would minimize handling of master tapes and cards through automatic call-out.

At least one machine will read from punched-paper tape, receive key-board entry, automatically perform calculations, and promptly type and punch results. A similar unit uses punched IBM cards as input rather than punched tape. Still another machine types and prepares cards for by-product usage.

A large department store chain is reported to be progressing favorably with another integration system. Automatically, point-of-sale charge and merchandise item information will be simultaneously recorded in sales, accounts receivable, and inventory accounts. To speed its accounting processing, the American Bankers Association is said to be considering the use of magnetic printing inks.

Master Tape Utilization

Western Electric manufactures and supplies telegraphic equipment to both American Telephone and Telegraph and Western Union. Equipment of either Commercial Controls or Western Electric can process a business document while reading from a previously prepared tape and simultaneously obtaining a by-product tape of selected data. The by-product tape contains information either manually entered on the keyboard or introduced from the master information tape being read.

The preedited master tape permits accurate entry of repetitive data at speeds faster than typing. Moreover, master tapes can be filed and reused indefinitely. Single-tape readers and single-tape punches, can be operated in tandem to perform multiple reading and/or punching.

Punched-Paper Tape

Punched-paper tape systems vary from five to eight codes per row. Each row, or "channel" as the row is commonly termed, represents one character of information.

The five-channel code system in widest usage today is the only one that can be transmitted or received with conventional equipment. Highly accurate, it has the drawback of lacking a parity check. Also, the operator must shift from alphabetic characters to numeric, and vice-versa. The keyboard is restricted to upper-case type face only.

Variations of the six-, seven-, and eight-channel code systems provide one or more of the missing features.

Audit of Input

The parity check is a facility wherein punch accuracy is verified, row by row, for an odd or even pulse to ascertain validity. This checking method is considered adequate to insure valid data perpetuation. It is commonly used as a checking method in electronic computers. When one considers the operational cost of a large-scale computer system is over three hundred dollars an hour, elimination of all possible error prior to computer entry becomes essential.

In any IDP checking operation, the point of original data entry provides the best verification facility. At such inception level, extreme accuracy must be exercised because incorrect data can be just as quickly self-perpetuated as correct data . . . and the machines don't know the difference. Statistics show that subsequent checking in any office routine is ineffective; the ultimate answer, therefore, is to eliminate the error at source level.

Use of master tapes to introduce data mechanically is presently the favored approach. Of course, master-tape information must be fastidiously screened, but the cost entailed by this requisite is minimized as a result of reusage and self-perpetuation features.

Inasmuch as the operator ordinarily has reference to the prepared document, sight verification of variable data (keyboard introduced) is easily accomplished.

Utilization of By-Product Tapes

Self-perpetuation of data in an IDP system is accomplished by transmitting by-product tapes from one location to another. Because these tapes contain only selected data and can be accurately transmitted at high speed, the perpetuation feature becomes highly advantageous.

Transmission speeds vary from sixty-five words per minute to over two hundred words per minute; testing is currently being done at 1,000 words per minute.

Of course, the tape is of little use to tabulating or electronics processing if it cannot be converted easily into the common equipment language of punched cards or magnetic tape. Either is possible. Automatic machines are available for converting from tape to card, and vice-versa, and for use as direct input equipment as well. This adds considerable flexibility in the development of any system of integrated-data processing.

Both perpetuation and conversion minimize manual recopying—eliminating it entirely in many cases; they also do the same for tabulation and electronics. This probably offers the largest single area for effecting savings in IDP because key-punching, key-verifying, copying, and checking are slow and costly processes, with inherent error ratios much in excess of conversion of tapes or cards.

Continuous Work Flow

Another specific benefit provided by a well-designed IDP system is continuous work flow. "Batching" of work is a difficulty frequently resulting from departmental specialization wherein the peaks and valleys of one department's work load correspondingly affect each subsequent processing unit.

Staff balancing, scheduling problems, and work back-logs are topics of too frequent discussion; all too often a major crisis results from erratic paperwork production-flow.

All business people are conscious of that "mountain" of morning mail which hits their desks and of the subsequent difficulties from time to time in handling and distributing it rapidly. Continuous work-flow measurably relieves office hypertension and provides improved working efficiency with fewer backlogs.

Literature Cited

1. Canning, R. G., "Input and Output," John Wiley & Sons, Inc., New York, p. 98 (1956).

Presented at A.I.Ch.E. meeting, White Sulphur Springs, West Virginia.

EXAMPLE—AN IDP SYSTEM AT WORK

The sales order-system provided the basic reason for the Diamond Alkali-IDP system with other contributing factors, such as frequent order delays encountered with ordinary mail; a three-day invoicing cycle that bulked work; pyramiding toll-call expense incident to rush shipments of increasing frequency; and general elimination of work duplication and inaccuracies existent in the entire order-shipping-invoicing routine.

Presently the entire IDP system is "on stream," carrying communications traffic, IDP order system, daily inventory, and daily production reports. The company estimates its annual operating cost will approximate $60,000, with offsetting reductions in toll calls, processing economies, improved customer service, and improved plant scheduling; it anticipates an annual savings return of $15,000 effective later this year.

SCOPE OF SYSTEM

The system embraces eighteen plants and ten sales offices in geographic extremities of New York City, Houston, and St Louis.

Previously, the complete order-shipping-invoicing cycle required sixty hours; now less than twenty hours are required. An order can be transmitted within two minutes between any two locations, and nearly 80 per cent of all data are self-pepetuated in the system.

EQUIPMENT UTILIZED

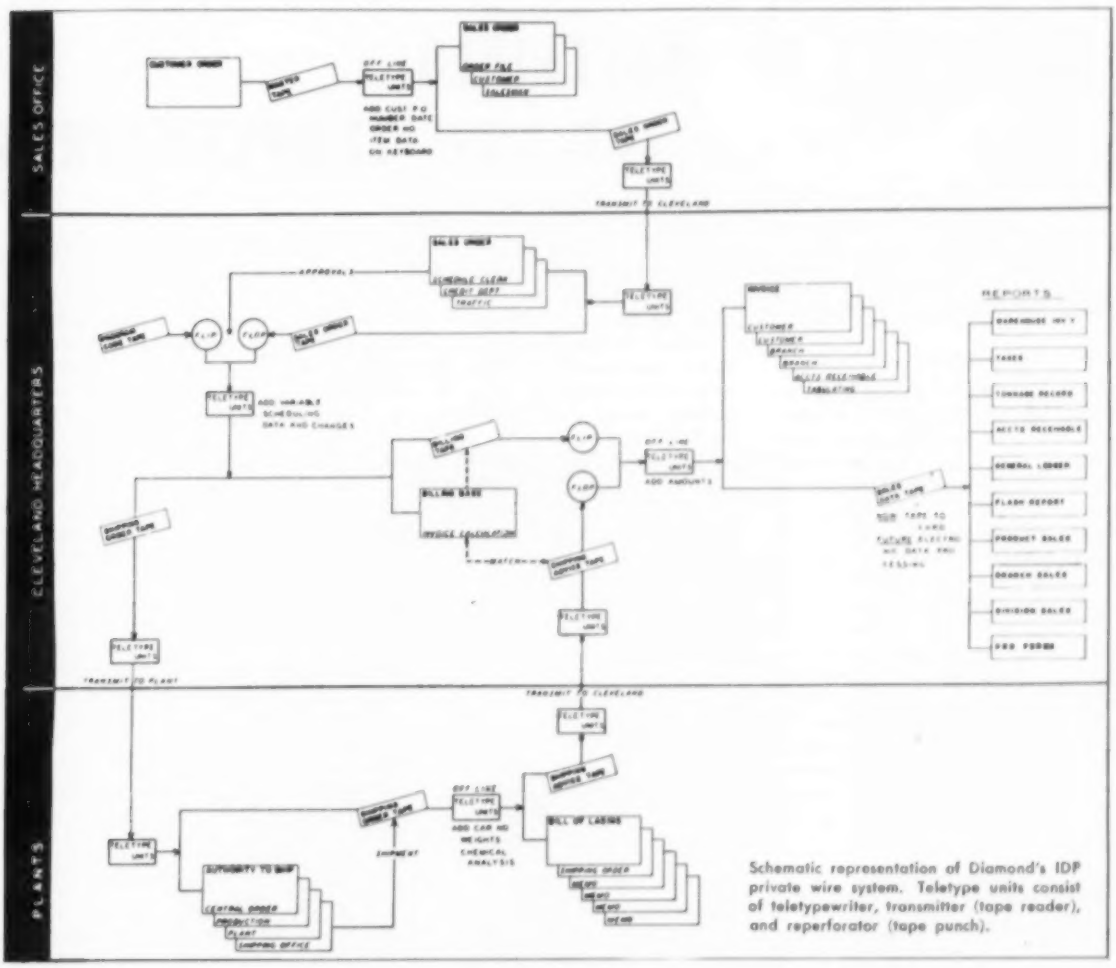
The systems staff had two major objectives in mind in developing the philosophy of data integration:

1. The system should serve all data-processing requirements. This has been achieved through perpetuation of data contained in the sales order through all subsequent levels of document processing and reporting. 2. In less than two years, the intentions are to connect the integrated system directly to a medium-scale computer to schedule production and replenish branch warehouse inventories. This will improve the reporting ability for all order and sales information. A centralized plant standard-cost processing routine will also be included on the computer; this and auxiliary routines will utilize the IDP system more extensively at time of statement closings. Line coding techniques will be employed to minimize lengthy data descriptions.

Model 28 teletypwriter (Ohio Bell) serves as a mechanical robot in the system, directing the operation of some twenty-one functional codes. These codes, much likened to computer programming, instruct individual units to start, read, punch, type (or "blind" type), or stop; this obviously permits data to be included or excluded at will at any location.

Another special feature of the system is the "flip-flop," wherein two tapes are automatically and alternately read to combine selective information.

With a look toward tomorrow, dynamic reporting results are anticipated when IDP and EDP are linked together as one aggressive team. Results to date have proven that IDP is reliable as a data collector and as an external data processor, and will provide a solid foundation in computer processing to supply management with better facts, faster.



Schematic representation of Diamond's IDP private wire system. Teletype units consist of teletypewriter, transmitter (tape reader), and reperforator (tape punch).

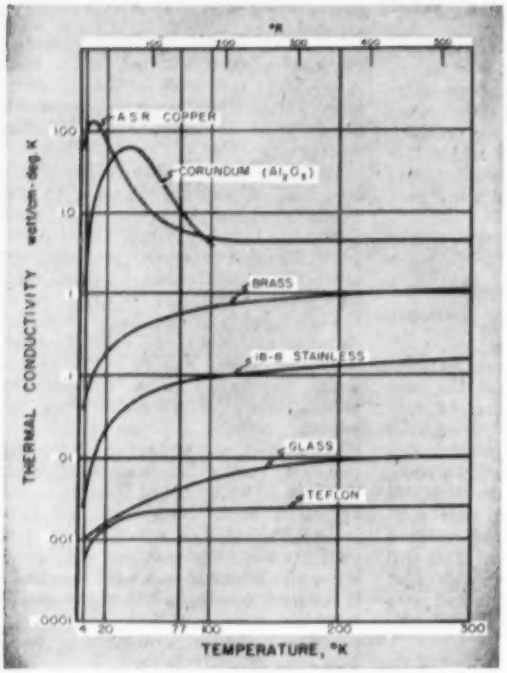


Fig. 3. Some thermal conductivities showing temperature variations characteristic of (a) pure metals: copper; (b) dielectric crystals: corundum; (c) alloys: brass and 18-8 stainless steel; (d) glassy solids: glass and Teflon.

R. J. Corruccini

Cryogenic Engineering Laboratory
National Bureau of Standards
Boulder, Colorado

PROPERTIES OF MATERIALS AT LOW TEMPERATURES

(PART 2)

(*Part 1 appeared in the June issue*).

Thermal Conductivities

Heat is conducted in solids by two parallel but not independent mechanisms: one the thermally excited lattice vibrations associated in the first section with the specific heat, and the other the thermal motion of free electrons. It has become conventional to express the first of these in terms of the quantum mechanical particle equivalent of a lattice wave called the phonon. Electrical insulators lack free electrons and hence show only phonon (lattice) conduction. Metals and semiconductors show both types of conduction, though one or the other may predominate. The simpler case of the electrical insulators or dielectric solids will be considered first. A detailed review of heat conduction in these has been given by Berman (*19*).

DIELECTRIC CRYSTALS

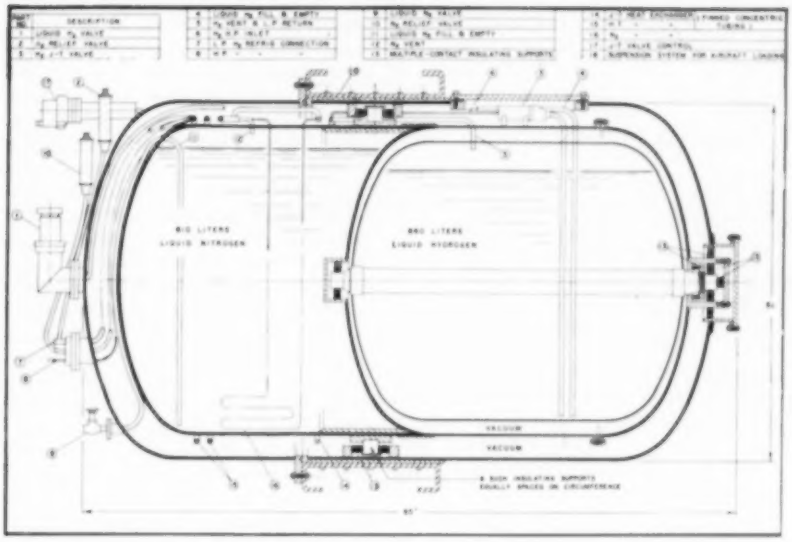
An ideally perfect lattice of infinite extent would have a resistance to conduction by phonons that was determined entirely by their *mutual* scattering. With falling temperature this scattering decreases rapidly since it is a function of the anharmonicity of the lattice vibrations, and this is strongly temperature-dependent. Thus the conductivity would rise without limit as the temperature falls. The right-hand portion of the curve for corundum in Figure 3 exemplifies this behavior. An alternative statement appropriate to the concept of the phonon as a particle is that its mean free path in a phonon "gas" increases with falling temperature. The conductivity is given by an equation similar to the kinetic theory expression for the conductivity of a gas

$$K = \Sigma\, cv\lambda/3 \qquad (14)$$

where c, v, and λ are, respectively, the heat capacity per unit volume, the velocity, and the mean free path of lattice waves of a given frequency, and the summation is carried out over all frequencies and the three possible polarizations.

In a real crystal of high perfection the rise of the mean free path and of the conductivity with decreasing temperature is limited by the finite extent of the lattice. Phonon scattering then occurs primarily at crystal boundaries, and the corresponding resistance increases with falling temperature so that the conductivity ultimately decreases again as in the left-hand branch of the curve for corundum. (This curve was obtained with a single crystal of 3-mm. diam. by 6 mm. long. It will be noted that high values indeed were attained, i.e., fifteen times the room temperature conductivity of copper.)

In the region where boundary scattering predominates, λ in (*14*) is fixed by the crystal size and, since the velocity is usually nearly temperature-independent, the conductivity shows approximately the same temperature variation as does the specific heat. A similarity between this situation, free-molecule gas conduction, and radiation exchange between surfaces will be noted in that in all three cases heat is transferred by means of a particle that interacts only with its confining boundaries. In all three cases, a conductivity can be defined but is artificial, since it is not a property of the medium

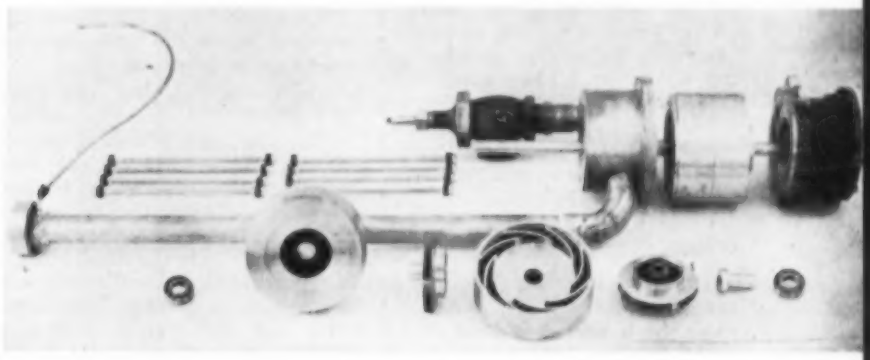


Construction drawing of 840-liter air transportable dewar for hydrogen.

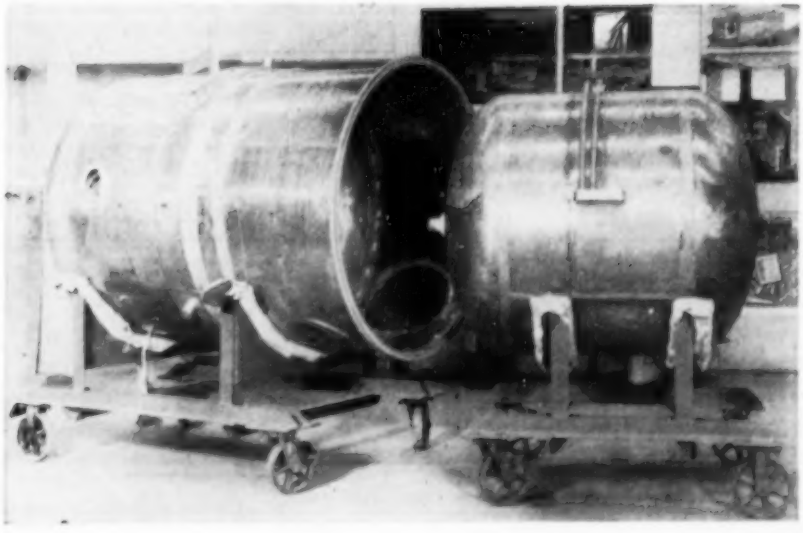


View of a pump (partly disassembled) for liquid hydrogen developed at the Boulder, Colorado, Cryogenic Engineering Laboratory of the National Bureau of Standards.

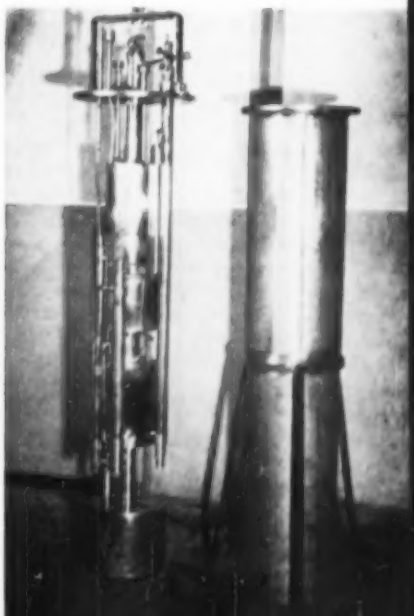
Liquid hydrogen pump broken down.



Assembly of 840-liter air transportable dewar.



15-liter/hr. hydrogen liquefier built at the Boulder laboratory (partly disassembled).



The **Notation** and **Literature Cited** portions of this article appeared in the June issue, pages 266 and 267.

alone, and its value is dependent on the separation of the boundaries and the manner in which the particle interacts with them. The conductivity of *polycrystalline* dielectrics is decreased as the crystallite size is made smaller, the portion of the curve to the left of the maximum being most strongly affected. Thus Berman found that sintered corundum with grain sizes in the range 5 to 30μ had a maximum conductivity only one fortieth as great as the sample shown in Figure 3 and displaced to a somewhat higher temperature.

The phonon-interaction and boundary-scattering processes establish the general shape of the conductivity curve for a perfect crystalline dielectric. Further scattering may occur at internal lattice imperfections such as vacancies, interstitial atoms, impurity atoms (among which may be included isotopes of the primary constituents), and dislocations. These added resistances have the effect of lowering and flattening the conductivity curve and, in the limit of a glassy or disordered solid, lead to a curve without a maximum.

GLASSES

The glassy state is characterized by the absence of long-range crystalline order. Such order as is found extends over only a few atomic or molecular diameters. In such a solid the scattering of phonons by the disordered structure is predominant, and the mean free path is approximately constant and determined by the size of the small regions of local order. In terms of Equation (14) the conductivity is

$$K = C_v \bar{v} \lambda / 3V \qquad (15)$$

where $\bar{v}$ is an average velocity. For inorganic glasses below the softening point, the velocity and volume are nearly independent of temperature, and if λ is fixed by the range of atomic order, then K should be proportional to C_v and the situation would be similar to that of predominant boundary scattering except that the "boundaries" are now fictional ones setting off the small regions of local order. This proportionality is found at ambient temperature, but as the temperature is lowered, K is found to decrease less rapidly than C_v. This effect sets in when the wavelength of the dominant lattice vibrations (which varies inversely with temperature) begins to exceed the range of order in the glass. The medium then approaches the behavior of an elastic continuum and the effect is as if λ were increasing with falling temperature beyond the limit previously set by the range of local order.

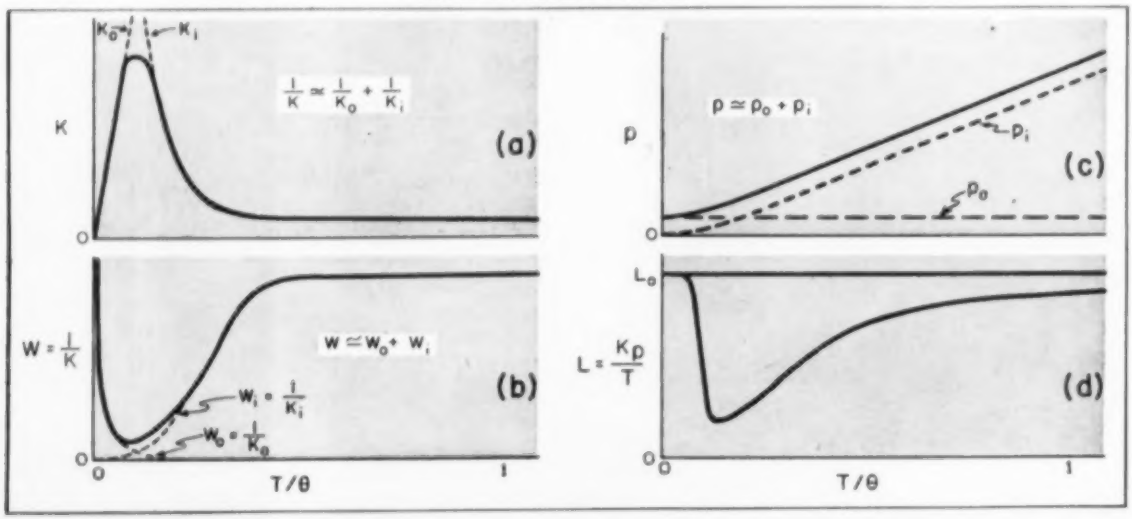
The curves for "glass" and Teflon in Figure 3 are characteristic of glassy solids. The "glass" curve is approximately representative of both fused silica and borosilicate glass. In these, assumption of proportionality between K and C_p for purposes of estimating one quantity from the other would, if the constant of proportionality were established with room-temperature data, lead to an error of 15% at 200° K. and 40% at 100° K. Eucken (*20*) has measured eight inorganic glasses down to 83° K. The curves are parallel to the glass curve in Figure 3 which lies intermediate in the group and which closely represents borosilicate glasses. This curve is within 40% of all varieties of glass that have been measured in the range 100-300° K. Fused silica is the highest in this group and lead and phosphate glasses lowest.

With Teflon the lack of proportionality between K and C_p is more marked since K decreases only about 10% from 300 to 100° K. while C_p is decreasing about threefold. Young's modulus for plastics increases sharply with falling temperature and Teflon is outstanding in this regard, its modulus increasing tenfold from 300 to 100° K. This increase in rigidity must correspond to a large increase in the wave velocity, $\bar{v}$, in Equation (15) overshadowing possible variations in λ, and consequently can account qualitatively for the failure of the conductivity to decrease rapidly with decreasing temperature.

Aside from the data shown on Teflon, measurements by Berman on nylon (*19, 28*) and an acrylic plastic, Perspex (*22*) in the region below 20° K., and a measurement of hard rubber in the range 83-273° K. by Eucken (*20*) seem to be the principal low-temperature data on polymers. With reasonable interpolations it appears that all these are within about ±35% of the value, 2½ Mw.(milliwatts)/(cm.)(° K.) from 100 to 300° K.

Conduction in *metals* and *alloys* has been reviewed by Olsen and Rosenberg (*21*), and a comprehensive compilation of data has been presented by Powell and Blanpied (*22*). The latter includes some selected data on dielectrics. Because of its completeness for metals no data will be included in this section except for some recent results.

Fig. 5. Schematic representation of (a) the electronic thermal conductivity, (b) the electronic thermal resistivity, (c) the electrical resistivity, (d) the Lorenz number for metals.



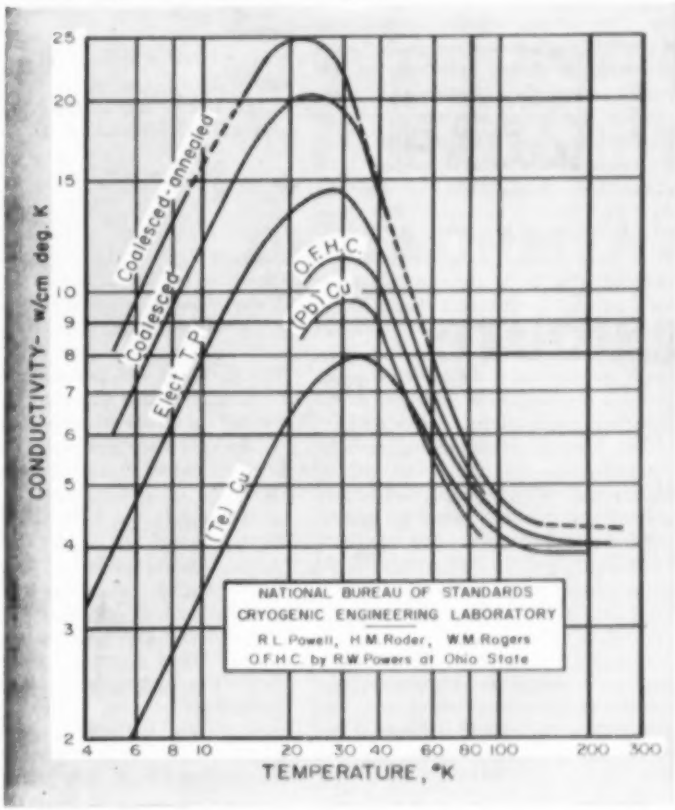
The shape of the curve for copper in Figure 3 is characteristic of pure metals. The lattice conduction has been greatly reduced by a new scattering agent, the free electrons, and is negligible compared to the electronic conduction. In a lattice of infinite extent without defects the only resistance to the flow of electrons is provided by the thermally excited departures of the lattice structure from perfect periodicity. The temperature dependence of this electron-lattice scattering determines the trend of the curve to the right of the maximum. Superimposed is a scattering of electrons by impurity atoms and other lattice defects such as vacancies, displaced atoms, and dislocations. The thermal resistance due to this fixed network of scattering agents has a different temperature dependence than that due to the lattice vibrations. It limits the rise of the conductivity with falling temperature and causes the conductivity to fall again to the left of the maximum.

These two thermal resistances are sufficient to account for the general shape of the conductivity curve. The height, and to a lesser extent, the location of the conductivity peak are sensitive to the number and nature of the residual lattice defects as is shown by the curves for a variety of commercial coppers in Figure 4 (*23*). These progress in purity upwards, being topped by the curve for the copper of Figure 3, also due to Powell, Roder, and Rogers, this copper being a special product with a purity of about 99.999%. The latter sample showed the highest conductivity yet recorded for copper, about 140 w./(cm.)(° K.), or over thirty times the room-temperature conductivity.

It is difficult to predict thermal conductivities of nearly pure metals on the basis of their chemical analyses because (1) the effect of each kind of impurity is specific and depends on its electronic band structure, and (2) the effect of a given impurity is much greater if it is in solid solution than if it is segregated at grain boundaries, and thus a gross or over-all chemical analysis provides insufficient information.

The second consideration is believed to account for the relatively poor showing of the OFHC (oxygen-free high-conductivity) copper. It is suggested that the removal of the oxygen has permitted metallic impurities that were previously segregated as oxides at the grain boundaries to enter the lattice. Similarly the quite good conductivities of the free-machining lead and tellurium coppers are realized in spite of the additives because the latter are soluble slightly if at all in the copper and thus are localized at grain boundaries (this condition being also responsible for the free-machining characteristic). The effect of eliminating physical imperfections, primarily dislocations, by annealing is shown by the two curves for coalesced copper.

Fig. 4. Thermal conductivities of some commercial coppers. "Coalesced" copper, 99.98% pure; "elec. T.P.," electrolytic tough pitch copper, 99.9+% pure; "OFHC," oxygen-free high-conductivity copper, 99.9+% pure, unpublished data by Powers, *et al.*; "(Pb) Cu," 99 Cu 1 Pb; "(Te) Cu," 99 Cu, 0.6 Te. All in "as fabricated" condition except "coalesced annealed" sample.



From Figure 4 it will be appreciated that there are pitfalls for the equipment designer who wishes to use copper to provide high thermal conductivity (say, for purposes of temperature equalization) especially in the region 10-40° K. The range of conductivities shown here is from a few to 140 w./(cm.)(° K.) and this group can be extended to include another commercial metal, nominally a copper, with a conductivity at 20° K. of only 0.4 w./(cm.)(° K.). This is phosphorus-deoxidized copper (99.8 Cu, 0.1 P) which is the material used in nearly all copper tubing and in some sheet and plate stock. The impurity scattering in this material is so great as to obliterate the conductivity maximum leaving a monotonically rising curve similar to that of brass in Figure 3 and about twice as high. This curve, if plotted in Figure 4 would barely enter the lower right corner. Of the coppers in Figure 4, electrolytic tough pitch is the most commonly available, being the variety used for most wire and for some of the production of plate and sheet. Finally it can be noted that all approach a common value at room temperature where the conduction is limited primarily by the thermal vibrations of the lattice and is insensitive to defect scattering.

The extreme sensitivity to impurity and cold-work of the low-temperature conductivity of nearly pure metals is in strong contrast to the specific heat and expansivity, both of which are somewhat sensitive to the type of lattice structure and to the interatomic forces, but relatively insensitive to local imperfections of the lattice. The variability shown by coppers is demonstrated by other metals and serves to illustrate that where the conductivity is concerned, there are no "pure" metals but only alloys of various degrees of

dilution. Fortunately for the peace of mind of the cryogenic designer the only other widely used cryogenic metal—aluminum—is available in only one nominally pure commercial grade.

ALLOYS

Of course, no sharp distinction can be drawn here between metals and alloys, but generally the latter term will mean a system in which the impurity scattering is so great as to overshadow the lattice scattering even at room temperature and also in which the conductivity maximum has been obliterated. Brass and 18-8 stainless steel in Figure 3 exemplify this class, the latter material and Inconel having about the minimum conductivities presently obtainable in commercial structural alloys. In the latter materials, as in elements having an abnormally small number of conduction electrons (bismuth, germanium), the lattice conductivity is not negligible compared to the electronic conductivity.

The problem of estimating metallic conductivities has been examined by White and Woods (*24*), who have pointed out methods based on experimental measurement of the electrical resistivity. This is a relatively simple experiment involving measurement of the potential drop in a sample carrying electric current. Since it is difficult to insure that the current leads will have negligible resistance compared to a sample at low temperature, it is best to attach to the ends of the sample two additional leads for measuring potential.

The electrical resistivity is controlled by the same factors as is the thermal resistivity, but the temperature dependences are different. Thus in Figure 5(*c*) the electrical-resistivity curve of a fairly pure good-conducting metal consists of a varying portion in which scattering of electrons by temperature-controlled lattice vibrations is the dominant factor and a constant region at the lowest temperatures, the "residual" resistance, where impurities and defects control. The two kinds of resistance are approximately additive (Matthiessen's rule) provided the residual resistance, ρ_0, is not more than a few times as large as the lattice or "ideal" resistance, ρ_i, that is, the effect of moderate variations in impurity level is approximately represented by shifting the ρ curve vertically. Matthiessen's rule is applicable also to the thermal resistivity. Thus

$$W = \frac{1}{K} = W_a + W_i$$

where $1/K_a = W_a$ is the residual or impurity thermal resistivity and corresponds to the initial linear part of the K curve [see Figures 5(*a*)-(b)], while $1/K_i = W_i$ is the ideal thermal resistivity (due to lattice vibrations). The electrical and thermal conductivities are correlated through the Wiedemann-Franz-Lorenz ratio, $L = K\rho/T$. At the lowest temperatures where K is proportional to T and where ρ is constant, the Lorenz number, L, is constant and has the value $L_o = 2.45 \times 10^{-8}$ w.ohm/(° K.)², given by theory. Again at temperatures of the order of θ_D and higher (i.e., room temperature for most metals) L has the same value, provided it is expressed in terms of K_i and ρ_i. Thus K can be estimated at these two extremes of temperature from corresponding values of ρ. For most metals, the low-temperature region of constant ρ and linear K includes the boiling point of helium, 4.2° K., but does not extend so far as the boiling point of hydrogen, 20.4° K., unless the element has a high θ_D value. A measurement at 4.2° then gives ρ_o directly while a measurement at room temperature, T_r, gives $\rho_r = \rho_{ir} + \rho_o$.

Combining these results one can calculate $K_o = L_o T/\rho_o$ and $1/K_r = 1/K_o + 1/K_{ir} = \rho_o/L_o T_r + \rho_{ir}/L_o T_r$. Unfortunately L departs from L_o at intermediate temperatures in the manner shown in Figure 5(*d*), the amount of the departure depending on the purity. However, at intermediate temperatures W_i can be approximated by means of the semiempirical formula (*25*)

$$\frac{W_i}{W_{ir}} = 2\left(\frac{T}{\theta}\right)^2 J_3\left(\frac{\theta}{T}\right) \qquad (16)$$

where

$$J_3\left(\frac{\theta}{T}\right) = \int_0^{\frac{\theta}{T}} \frac{x^3 dx}{(e^x - 1)(1 - e^{-x})} \qquad (17)$$

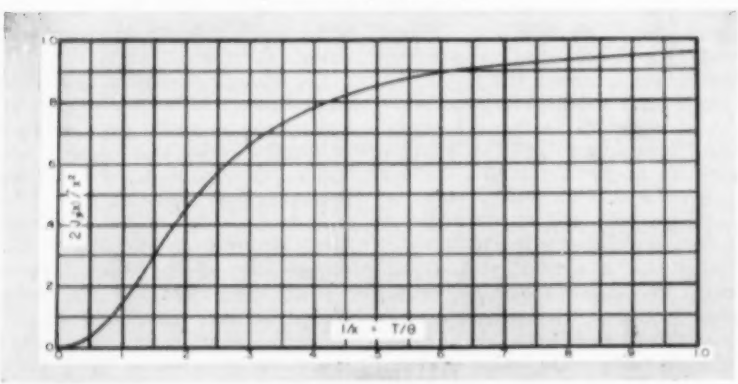
and θ is to a good approximation, the same as θ_D. The function $2J_3(x)/x^2$ has been calculated by Dank and Barber (*26*) (their function, C_2/C_x) and is shown in Figure 6, this graphical form being sufficiently accurate for interpolating between values of K_o and K_r obtained using the W-F-L ratio.

This procedure seems to give satisfactory results (within perhaps 20%) for nearly pure good-conducting metals and fortunately so, for this is the case, as Figure 4 illustrates, where the large possible variation among nominally similar materials makes it most desirable to have a simple means of checking individual samples. White and Woods suggest that it should be equally good for alloys for which $\rho_o/\rho_r = \frac{1}{2}$. This is equivalent to ρ_r of the alloy being not more than about twice the value of ρ_r of the major component and rules out the poorer conducting alloys in which lattice conduction is significant. Such alloys are marked by abnormally high values of the Lorenz number. Estimation procedures for these are less satisfactory but are also less necessary since the cryogenic engineer will usually be utilizing established commercial alloys. Considerable information is available on the conductivities of these (*22*), and they are in any case a more closely grouped family than the metals and not as highly sensitive to variations in composition or cold-work.

In closing this section on thermal conductivity one can note that Klemens has recently given an extensive treatment of the theory (*27*). Since the appearance of the compilation of data (*22*), a number of new experimental papers have appeared of which only one by Berman (*28*) is devoted to technical materials. This gives data on brass, beryllium copper, soft glass, nylon, soft solder, and Wood's metal in the region below 90° K.

Part 3 will follow in the August issue.

Fig. 6. The ideal electronic thermal resistivity interpolation function. J_3 is defined by Equation (17).



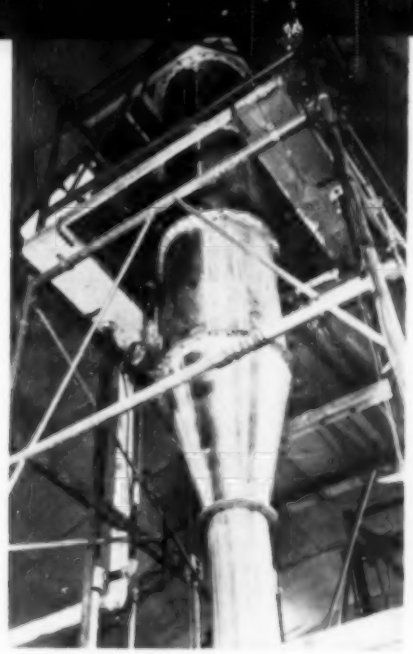


Fig. 1. Laboratory spray dryer, showing 20-in. diam. upper section and 8-in. diam. lower section.

EXPERIMENTAL SPRAY DRYER FOR PRODUCT DEVELOPMENT STUDIES

E. J. Crosby * *and W. R. Marshall, Jr.* | University of Wisconsin, Madison, Wisconsin

A small experimental spray dryer has yielded particle sizes in the same range as usually produced in commercial dryers. Concurrent as well as counterflow drying are possible; air-flow patterns are kept symmetrical at any flow rate by simple external controls. Evaporative loads of 10 lb./hr. are sufficient for most product development studies, permit variety of tests within short time. Ten different runs have been made in as little as two hours, permitting establishment of effect of two variables on product properties.

The chemical engineer engaged in product development frequently needs an experimental spray dryer to provide data primarily on the properties of spray-dried products rather than for the development of dryer design data. The dryer described here was designed for this purpose.

The general requirements for a spray dryer for product development studies are briefly summarized as follows:

1. The drying chamber should be large enough to minimize wall build-up. Although this can be accomplished with an extremely large chamber, such a procedure would not be feasible on a laboratory scale.
2. The height of the dryer should be sufficient to investigate the drying of large particle sizes, 200-500μ. In this study,, the height was selected as high as was compatible with the available headroom.
3. Air flow patterns should be such as to delay transfer of the drops to the walls of the dryer as long as possible.
4. The atomizer should produce droplets in a size range which can be dried within the physical limits of the dryer. The atomizer should have also a narrow dispersion angle in order that a wide range of drop sizes could be dried and recovered. At the same time good mixing between the spray and the drying gases should be achieved.
5. After drying is accomplished, separation of the product from the drying air should be such that the particles are not mechanically injured, nor allowed to remain in direct contact with the drying air over an extended period of time.
6. The dryer should be flexible from the standpoint of both drying conditions and dryer configuration.

The laboratory dryer shown in Figure 1 met the above requirements and was used in this study. It was a modification of the one reported by Duffie (*2*).

Description of Experimental Spray Dryer

DRYING CHAMBER

The over-all height of the dryer was 20.5 ft., and the effective drying height was 19 ft. Cylindrical in cross section, the upper portion of the tower was 20 in. diam. and was composed of three sections 29 in. long. The lower portion of the tower was made up of three 30-in. sections, 8 in. diam. and was connected to the upper 20-in. portion by a conical section, as shown in Figure 1.

The rather novel feature of having the dryer converge from a large upper section to a small lower section, rather than being of constant large diameter, was the result of increasing only the upper half of the Duffie tower (*2*) from 8 in. to 20 in. diam. The diameter of the upper section was established from the observed magnitude and persistence of the cone angle of the pressure nozzle which was used.

The length of the 20-in. diam. section was estimated from the results of exploratory spray-drying experiments carried out in the original 8-in. diameter equipment with a pneumatic atomizer. These experiments were made with sodium sulfate over a range of conditions, and indicated that the majority of the build-up occurred at about 7 ft. from the top of the tower.

The dryer was fabricated of 304 stainless steel. Low carbon steel was used for the flanges. Above and including the conical section, the tower was fabricated from 16-gauge metal and below this point 18-gauge metal was used. The flanges on the large sections were made from ¼-in. stock whereas the flanges on the smaller sections were made from 3/16-in. stock. The tower was constructed such that only stainless steel was exposed to the interior.

The drying tower was not insulated. Measurements of longitudinal temperature gradients in this unit indicated that in comparable operating conditions the heat losses were no worse than that realized in an 8-in. diam. dryer lagged with 2.5 in. magnesia.

* E. J. Crosby's present address is Du Pont Company, Wilmington, Delaware.

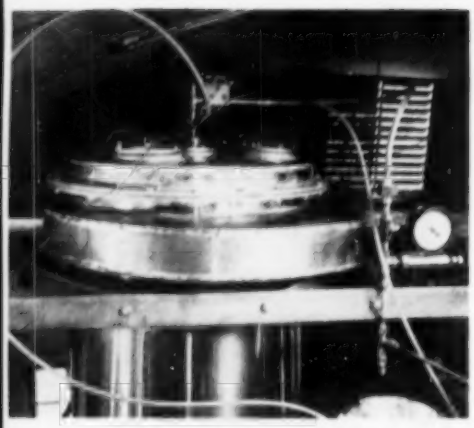


Fig. 2. Top of laboratory spray dryer, showing viewing ports, atomizer in place, and annular air distributor ring.

Three ports were located at the top of the drying tower for observation of the interior of the tower during drying. Figure 2 shows the top of the dryer with the viewing ports and other auxiliary equipment in place. Small 1-in. ports were located at approximately 30-in. intervals down the wall of the dryer for access to make temperature measurements.

Air Supply and Distribution

The drying air was supplied by means of a turbine blower from an aircraft turbosupercharger driven at 5,200 rev./min. by a 5-hp. electric motor. The air quantity was controlled by means of a 7-in. blast gate attached to the suction side of the unit. Circular duct work, 5 in. diam. and formed from 20-gauge galvanized iron, was used to connect the blower to the tower inlet.

The drying air entered and passed through the dryer concurrent with the spray. This arrangement afforded the greatest simplicity in design and operation of the unit. It was not intended to study countercurrent spray drying with this dryer. However, the dryer could be readily adapted to countercurrent operation.

Fig. 3. Interior of top of laboratory spray dryer, showing air distributor ports and vanes.



In order to obtain as much drying height as possible, the air was brought into the drying chamber at right angles to the tower axis through an annular ring arrangement. The cross-sectional area of the ring was decreased symmetrically as the circumferential distance from the point of entry increased. This arrangement was intended to produce uniform air flow into the drying chamber around the periphery at the top of the tower.

This method alone did not give a uniform air flow pattern in the drying chamber. Numerous auxiliary methods for producing the desired flow pattern, such as baffles and/or distributor plates, were investigated by means of a small model and were found to be unsuitable. However, as a result of these studies, an alternative method was devised.

Six equally spaced rectangular ports from the annulus were used through which the drying air entered the tower. The flow rate through each of these ports was equally proportioned by adjusting the resistance of each port. This was accomplished with varying thicknesses of glass wool filter sheets supported by 200 mesh stainless steel screening. It was found that tangential swirl and eddy currents could be markedly reduced by a simple arrangement of radial vanes extending from the center of each port. Therefore, a 4-in. vane, projecting radially towards the axis of the tower, was placed in the center of each port.

This arrangement is shown in Figure 3.

Some typical air flow patterns obtained with this air-distributing system are given in Figures 4, 5, and 6. The axial velocities were measured at three different volumetric air flow rates at three levels below the top of the drying tower.

A Hastings hot-wire anemometer employing a unidirectional probe was used for measuring the point velocities. To obtain a continuous circumferential measurement of velocities, the anemometer probe was held on an arm which rotated one revolution every 12 min. and its output was fed directly to a recording potentiometer. Electrical contacts were made by means of silver slip-rings. While the velocity measurements were being made, it was not possible to have the dryer outlet in position.

All adjustments on the air distributing portion of the dryer were made at a flow rate of 88.3 cu.ft./min. Figures 4, 5, and 6 show the results of the velocity profile measurements when the flow rates were above, below, and equal to the rate at which the distribution mechanism was adjusted. At none of these flow rates were any rotational or swirl velocities detected.

When the flow rates were higher than those for which the distributor arrangement was adjusted, the high velocity vectors occurred on the side of the tower opposite from which the air entered. At lower flow rates the high velocity vectors occurred on the same side of the tower as the air entered. Therefore, in order to maintain a uniform flow pattern at any particular flow rate, the pressure drop through each entrance port in the annular ring should be adjusted according to that rate. With the present arrangement of controlling the pressure drop this is not feasible. However, a mechanical means such as adjustable baffles controlled from outside the tower might be a solution to this problem.

The drying air was heated electrically with two 3,000-w. and one 6,000-w., 220-v. heating elements.

Although there was one disadvantage to this type of heater in that it had a low capacity at high temperatures, it was used for the following reasons:

1) to produce low humidity drying air

2) to alleviate the necessity of using either gas or oil which was undesirable not only from an equipment size and location standpoint, but also from a safety viewpoint in the research area

3) to give a sensitively controlled heat source

4) to produce a high temperature not possible with steam.

Atomization

A centrifugal pressure nozzle was selected for atomization. Conceivably any of the three basic types of atomizers could have been used, but two were rejected for the reasons given below

From an operational standpoint the spinning disk was the most desirable as it was adaptable to handling a great variety of feeds with less problem of clogging its discharge ports. However, the drying chamber used with such an atomizer must be of a sufficient radius to prevent the wet particles from adhering to the walls. The small diameter of the tower obviated the use of the spinning disk.

A pneumatic atomizer also had the advantage of being able to handle a wide variety of materials. However, one disadvantage was the extreme turbulence caused by the pumping action of the atomizing gas which tended to cause excessive build-up at the top of the dryer.*

* In spite of this apparent disadvantage, a pneumatic nozzle operated at low air pressures was used successfully in studies subsequent to this and was found to perform sufficiently satisfactorily to be considered entirely acceptable as an alternate method of atomization for viscous liquids.

The pressure nozzle had the disadvantage that at low feed rates it was necessary to use a small orifice to obtain atomization. This aggravated problems of plugging and caused erratic operation. Nevertheless a pressure nozzle was selected to give a narrow cone angle. Its drop-size characteristics could be determined readily, and it produced a minimum amount of turbulence inside the dryer.

The nozzle employed was of the grooved-core type.

Orifice diameters ranged from 0.006 to 0.0135 in. and the core had two grooves, each 0.006 by 0.004 in. Because the orifice inserts first were drilled and then heat treated, the nominal diameters and the actual diameters were not in agreement. Table 1 gives the true orifice dimensions.

The nozzle body was of stainless steel and the inserts and cores were of "corrosion resistant" carbon steel.

The operation of this atomizer, with the prescribed dimensions, was somewhat erratic in the sense that the cone angle and degree of atomization appeared to vary periodically over a period of time. It was found that this was due to the difficulty in obtaining a good fit between the faces of the core and the spin chamber. At the small flow rates dealt with, the hydraulic pressure against the core was not sufficient to aid in seating it against the spin chamber. Consequently, a fraction of the liquid did not pass through the grooves and the degree of atomization and cone angle were thus affected. This situation was only partially remedied by placing a spring behind the core to aid in seating it.

Capacity tests with water were made over a six- to eight-fold pressure range. Figure 7 illustrates the results of these measurements. It was found that for the relationship $Q \sim P^n$, the exponent, n, was somewhat less than the value of 0.5 reported by Darnell (*1*) for this type of nozzle. Table 2 compares the values of the exponent with the dimensions of the nozzle. The results for the 0.010-in. diam. orifice indicated that there might be leakage of the liquid around the core of the nozzle. As a check on the reliability of these determinations capacity measurements were made with the 0.006-in. diam. orifice without the core in the nozzle. This test yielded a value for the exponent, n, of exactly 0.5.

The discharge coefficients and flow numbers were also calculated and related to the operating pressures as shown in Figures 8 and 9. Normally, the discharge coefficient, K, defined in terms of pressure P, orifice radius R_o, and nozzle capacity Q,

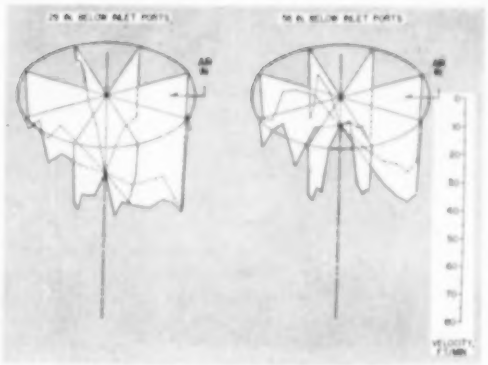


Fig. 5. Velocity profiles measured in laboratory spray dryer at 61.7 cu.ft./min. (air distributor adjusted at 88.3 cu.ft./min.).

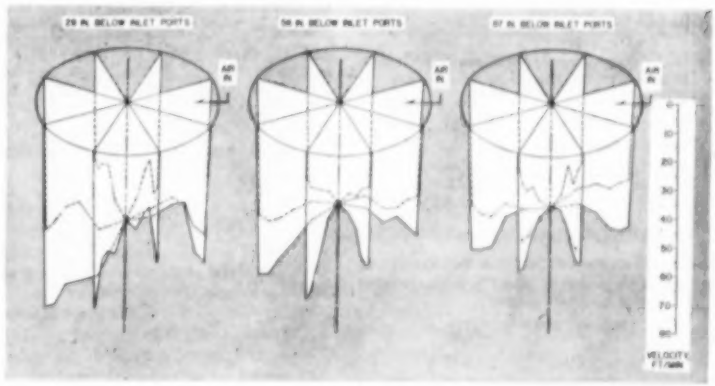


Fig. 4. Velocity profiles measured in laboratory spray dryer at 158.0 cu.ft./min. (air distributor adjusted at 88.3 cu.ft./min.).

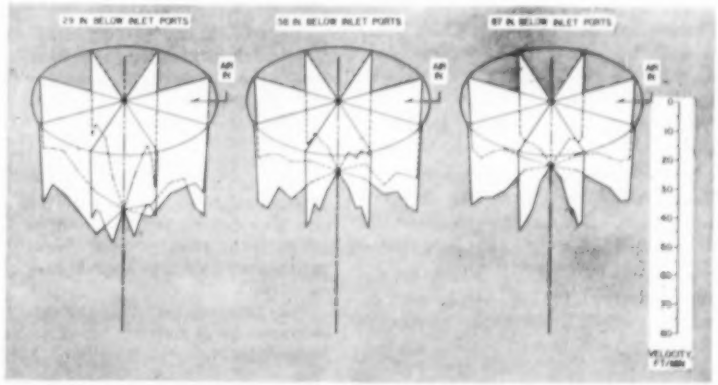


Fig. 6. Velocity profiles measured in laboratory spray dryer at 88.3 cu.ft./min. (air distributor adjusted at 88.3 cu.ft./min.).

Table 3.—Product Recovery From Laboratory Spray Dryer While Drying Coffee Extract

Run No.	Feed concentration, %	Feed rate, lb./hr.	Air rate, lb./hr.	Dry-bulb Air T. ° F. Inlet	Outlet	% Solids recovery
Co-1	22.0	5.42	203	513	222	97.5
Co-2	13.6	5.14	203	518	217	83.8
Co-3	7.0	5.04	202	500	212	88.8
Co-4	22.0	5.42	290	419	221	77.0
Co-5	13.6	5.22	291	414	212	70.0
Co-6	7.0	5.02	293	417	206	79.9
Co-7	22.0	5.43	387	329	208	77.0
Co-8	13.6	4.89	409	324	208	59.0
Co-9	7.0	4.96	407	329	208	67.5

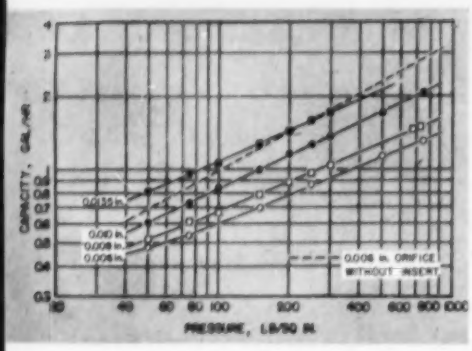


Fig. 7. Capacity-pressure curves for various nominal orifice diameters. (Same insert used with each orifice size).

Table 1.—Comparison of Nominal Orifice Diameters to the True Diameters

Nominal diam., in.	Actual diam., in.	Cross-sectional area, sq.-in.
0.006	0.00827	5.37×10^{-5}
0.008	0.00945	7.01×10^{-5}
0.010	0.0108	9.14×10^{-5}
0.0135	0.0150	17.58×10^{-5}

Table 2.—Variation of the Exponent, *n*, in the Relationship $Q \sim P^n$ with Nozzle Dimensions

2 Grooves, 0.006 × 0.004 in.

Nominal orifice diam., in.	*n*
0.006	0.392
0.008	0.403
0.010	0.464
0.0135	0.423

$$K = \frac{Q}{(\pi K_o^2)\sqrt{2g_c l'/\rho}} \qquad (1)$$

is independent of pressure. However, since the capacity for these nozzles was proportional to pressure to a power less than 0.5, K was not constant when calculated by the above defining equation.

Figures 10 and 11 show typical sprays formed by the nozzle used in this work while atomizing water at three different pressures. In none of these cases was the spray fully developed. The so-called "tulip stage" was evident more or less near the orifice at all pressures. It was observed that the tulip stage persisted more distinctly at higher pressures for the larger orifices as the photographs show.

Feed System

Figure 12 is a schematic representation of the feed system. The system was arranged to provide either water or feed to the atomizer as desired.

A positive displacement feed system was employed for two purposes: 1) to maintain a constant evaporative load on the dryer throughout the duration of a test run, and 2) to provide a means of checking the operation of the atomizer which could not be readily seen from outside the drying tower. Because of the variety of possible materials that might be dried and because of the ease with which a positive displacement pump may be injured by pumping certain solutions, the feed was displaced by a second liquid.

This was accomplished by storing the feed in a modified Vickers hydraulic accumulator. A Neoprene diaphragm separated the feed from the displacing liquid. When the diaphragm was completely distended, the accumulator had a capacity of approximately 1 gal. The second liquid was SAE 50 oil which was stored in an external reservoir when the accumulator was full of feed. The oil was motivated by a type B Zenith rayon spinning pump, which was driven through a variable-speed transmission.

The accumulator was mounted on an A frame and connected to the Zenith pump by a flexible high-pressure tubing. This allowed the feed side of the accumulator to be easily emptied and washed out at the end of a drying run. The oil and diaphragm were displaced by compressed air via a by-pass around the pump in preparation for a new run. The feed rate was determined from the time required for a given drop in the oil level in the reservoir as noted through a sight glass.

The pressure at the atomizer was measured by a bourdon pressure gauge located as near the nozzle as possible. Any irregularity in the nozzle operation was reflected in the pressure reading.

The atomizer was located inside the dryer such that the spray issued forth at a level even with the bottom of the air inlet ports. Prior to entering the atomizer, the feed passed through a line filter employing 100-mesh stainless-steel screen as the filter medium.

The feed temperature was controlled by a water jacket around the nozzle and the line filter was located adjacent to the nozzle. The temperature of the water in the jacket was controlled by passing it through a 30-in. tube-in-shell heat exchanger where throttled steam was the heat source. Further shielding inside the dryer was used to keep the hot gases away from this unit.

The temperature of the feed was measured at a thermowell located as close to the nozzle as possible. Because of the large mass of material making up the nozzle and the arrangement of the water circulation within the jacket, the temperature measured at the thermowell was considered not too different from that at the orifice.

Copper tubing was used throughout the feed system except beyond the location of the bourdon gauge. From here stainless steel was used including the flexible pipe which allowed the atomizer and jacket assembly to be easily inserted and removed from the drying chamber. The jacket assembly, gas shield, and thermowell were fabricated from brass.

Product Collection

Three separate methods of product collection were incorporated into the equipment. Each method was applicable for different types of products and situations.

Figure 13 shows the arrangement used for the collection of materials by free settling out of the air stream onto the floor directly beneath the drying column. This method was used when it was desired to remove a friable product from the air stream as quickly as possible. The diverging section, which had a cone angle of 25 degrees, decreased the linear velocities so that the majority of the product settled without being scattered far from the area covered by the cone. The one disadvantage was that a certain amount of fines was lost.

The second method of product collection was a cyclone separator. This equipment was attached to the dryer

Fig. 8. Variation in discharge coefficient with pressure for various nominal orifice diameters. (Same insert used with each orifice size).

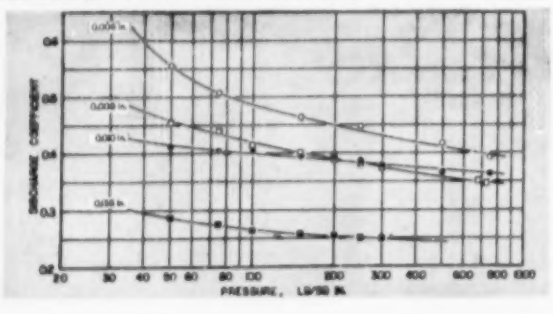
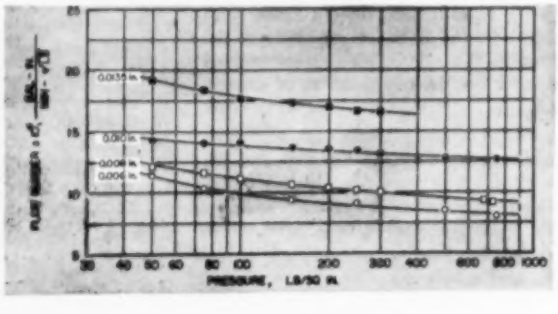


Fig. 9. Variation in flow number with pressure for various nominal orifice diameters. (Same insert used with each orifice size).



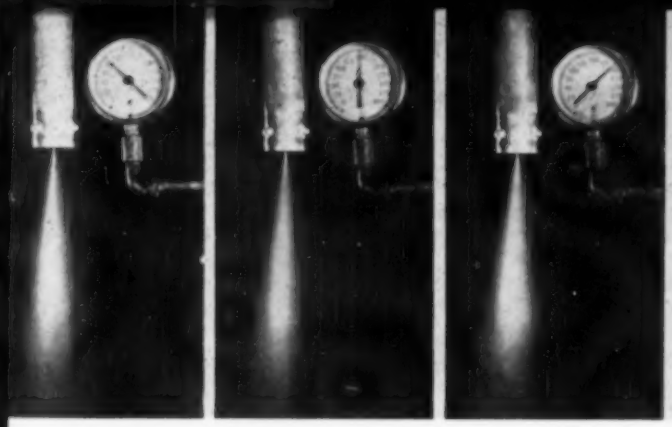


Fig. 10. Water spray formed by the centrifugal pressure nozzle used in the laboratory spray dryer with 0.006-in. diam. orifice at pressure indicated.

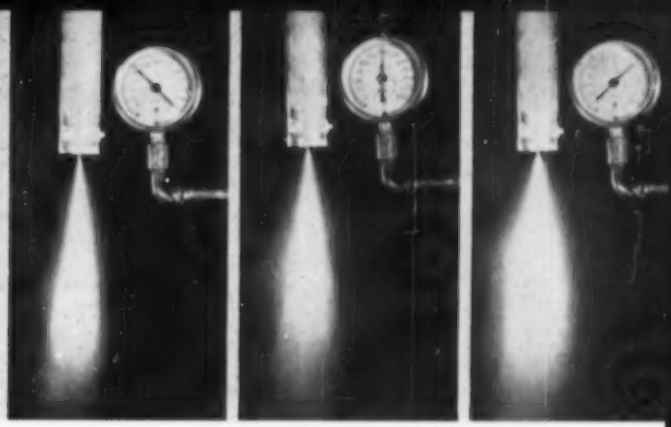


Fig. 11. Water spray formed by pressure nozzle used in laboratory spray dryer with 0.008-in. diam. orifice at pressure indicated.

as shown in Figure 14. The unit was of standard design (*3*) and had a diameter of 4 in. The collection efficiency experienced was, for all practical purposes, 100% over a range of local air rates from 50 to 125 cu.ft./(min.) for all materials dried. Sampling of the outlet gases by means of greased microscope slides indicated that a negligible amount of product was lost. However, this sampling procedure was not quantitative. Most of the dried solids were hollow and friable and were easily broken by attrition inside the cyclone. Hence this collector was used primarily to determine the amount of build-up within the dryer.

For the case where the total product was to be collected intact, a combination settling chamber and cyclone arrangement was employed as shown in Figure 15. The large, hollow, and friable particles settled out in the chamber and the smaller more dense particles were removed from the exhaust air stream by the cyclone. This combination yielded, under microscopic examination, no noticeable particle break-up.

Instrumentation

The air rate was measured by means of a venturi meter inserted in the straight section of duct between the blower and the heaters. Because the length of this section was only on the order of 10 ft., straightening vanes were installed ahead of the venturi.

All temperatures were measured with chromel-alumel thermocouple elements. The temperatures inside the drying chamber were measured with high velocity thermocouples.

Operating Procedures

Between 30 and 45 min. were required to bring the dryer near enough to steady-state conditions to start the drying operation.

The feed system, reservoir, and atomizer were thoroughly flushed with water before every drying operation. The nozzle proper was assembled outside the dryer and water was atomized under line pressure. Sometimes the line filter did not remove all particulate matter from the liquid or the nozzle would not have been cleaned well enough. Then, generally, the orifice would become plugged or a fully developed spray cone would not materialize because the insert and core did not seat properly. This necessitated a breakdown of the nozzle with further cleaning of its interior, insert orifice, and core grooves. Once the atomizer developed a full spray cone which lasted for a few minutes, no further mal-operation would be experienced throughout the complete drying run except under extremely rare circumstances. With water being properly atomized the water jacket for control of the feed temperature was put in place. The water which was being atomized was then brought to the desired feed temperature. All through this preparation period, which occurred simultaneously with the warm-up of the dryer, the output of the atomizer was fed into a basin connected to the drain.

The feed was prepared and/or diluted by direct weight measurement. After the feed reservoir had been flushed clean with water, the Neoprene diaphragm was distended to allow for maximum capacity. The reservoir was then completely filled with fresh feed and connected to the feed system. The piping assembly was so arranged as to allow negligible

Fig. 12. Schematic diagram of feed system used in conjunction with laboratory spray dryer.

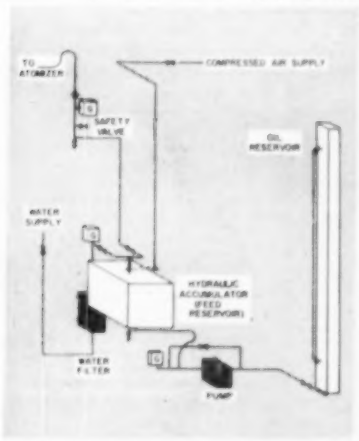
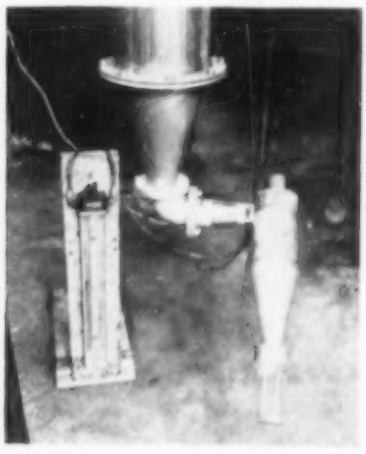


Fig. 13. Free settling collection unit.



Fig. 14. Cyclone separator collection unit.



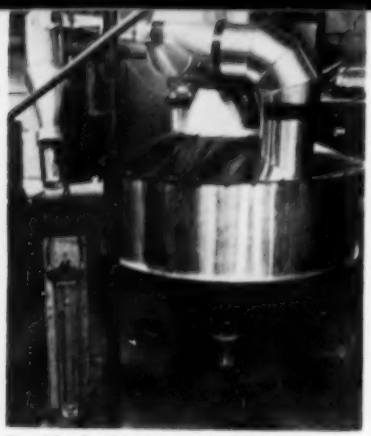


Fig. 15. Combination settling chamber-cyclone collection unit.

quantities of air to be trapped during this operation.

When the drying chamber had nearly attained thermal equilibrium, the valve to the feed reservoir was opened and the feed pump turned on. After a fraction of a minute the water valve was closed and only feed was being passed through the system. In this manner the liquid passing through the atomizer was gradually converted from water to pure feed stock.

Once the feed was being atomized satisfactorily, the atomizer assembly was inserted into the drying chamber. After a few minutes of drying, the feed and drying-chamber outlet temperatures were checked. Usually these two items needed a minor amount of adjustment due to a slight error in the prediction of the evaporative load and/or sensible heat gained by the feed by radiation and convection to the feed line over the top of the dryer. These corrections were quickly made and the dryer would be "on steam" between 5 and 10 min. after the beginning of the drying process.

Immediately after the atomizer was placed in position in the drying chamber the interior of the chamber was illuminated through one of the viewing ports at the top of the tower. The sequence of events inside the dryer was viewed through a second port by means of a mirror arrangement. Thus the air and particle flow patterns and build-up inside the drying chamber could easily be observed. This also gave a double check on the operation of the atomizer.

Efficiency of Laboratory Spray-Dryer Operation

Numerous materials, such as coffee extract, a clay slip, sodium sulfate, skim milk, an iron oxide-wax mixture, and a detergent have been successfully dried with the production of a wide range of particle sizes. At feed concentrations below 22 per cent solids droplets as large as 350 microns were dried. For feed concentration near 50 per cent solids dried particles as large as 1,500 microns were obtained.

The amount of product build-up experienced in this laboratory unit can be illustrated for several runs while drying coffee extract, indicated in Table 3. Although the degree of recovery may not appear good at first glance, the type of material being handled must be considered. For those materials which gave particle surfaces that were neither sticky nor pliable, sodium sulfate, for example, the recovery was greater under comparable operating conditions. Table 3 shows that product recovery with coffee extract is influenced by air temperature, air velocity, and solids content. The recovery increases with air temperature, decreases with air velocity, and shows a minimum recovery at 13.6% solids content, being greater above or below this concentration. These observations would be expected to be modified for other materials.

Figures 16 and 17 present the drying-chamber and over-all efficiencies experienced during the operation of the laboratory spray dryer. Although the data were scattered the trends are indicated.

The drying-chamber efficiencies were based on the evaporative load and energy lost by the entering air in its passage through the drying chamber. The over-all efficiencies were based on the evaporative load and the power consumed by the heaters and the blower.

It was of interest to note that sodium sulfate yielded higher efficiencies across the drying chamber than did the coffee extract. In some instances the clay slip evaporative loads were greater than those of the inorganic salt. This confirms the well-known fact that the drying efficiencies experienced in spray drying are related to the class of materials being dried, sodium sulfate being classed as crystalline and coffee extract as film forming.

A final important advantage of this experimental dryer should be noted: namely, the fact that its small capacity and flexibility permit making several tests under different conditions in a short period of time. Thus, it was found quite easy to make up to ten different runs in two hours and virtually establish the complete effect of two variables on product properties. This advantage is seldom realized in large experimental spray dryers.

Acknowledgment

The authors wish to express their thanks for financial support of this research to the Wisconsin Alumni Research Foundation, to Proctor & Gamble, Inc., and to the Engineering Experiment Station of the University of Wisconsin.

Literature Cited

1. Darnell, W. H., Ph.D. Thesis, University of Wisconsin (1953).
2. Duffie, J. A. and W. R. Marshall, Jr., *Chem. Eng. Progr.*, **49**, 417-23; 480-86 (1953).
3. Perry, J. H., "Chemical Engineers' Handbook," McGraw-Hill Book Company, New York, 3rd ed., p. 1023 (1950).

Presented at A.I.Ch.E. meeting, Seattle, Washington.

Fig. 16. Drying chamber efficiencies experienced in the laboratory spray dryer.

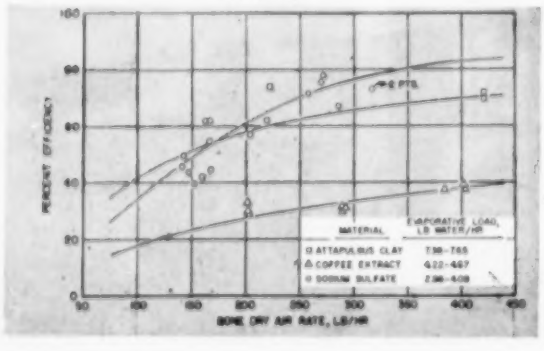
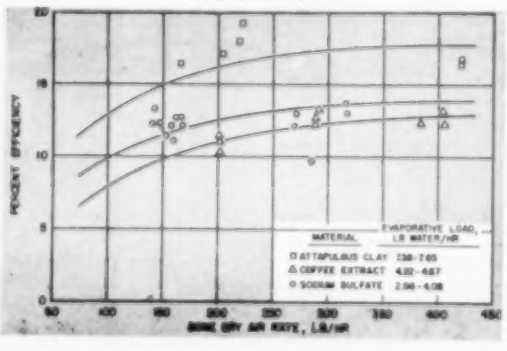


Fig. 17. Over-all drying efficiencies experienced in the laboratory spray dryer.



COMBATTING CORROSION in a PULP MILL —with STAINLESS STEEL

As a result of rigid specifications set up for the stainless alloys, improvements in design, fabricating, and operating techniques, an Alaskan pulp manufacturing company has realized the advantages of the corrosion resistant properties of the stainless steels for the production of high-quality dissolving grade sulfite pulp.

Joseph Kolberg | Ketchikan Pulp Company
Ketchikan, Alaska

Stainless steels, particularly Type 316, have been in use in the sulfite pulp industry for the past ten years and have shown excellent corrosion resistance to sulfite acids. As a result, stainless alloys have been increasingly used in existing sulfite pulp mills for the replacement of equipment such as pipe lines, valves, screens, and fittings. The new sulfite pulp mill which started production in 1954 at Ketchikan, Alaska, used more than the normal amount of stainless steels first, in order to produce a dissolving grade of wood pulp having a low metal content, and second, because of the acceptance of the magnesium-base acid-cooking system. This acid-pulping system includes the recovery of the spent sulfite acid and necessitated the installation of stainless steel equipment beyond that used in the conventional calcium-base sulfite pulp mill. Regardless of the success with stainless steels experienced in other sulfite mills, the experience at this new mill was such that the rate of attack by corrosion of the stainless steels in the first year and one half of operation was so severe that pulp production and pulp quality suffered.

An investigation was initiated to determine why the rate of corrosion of stainless steels at the Ketchikan mill was so much higher than that observed by other sulfite mills. This investigation established that the Ketchikan pulp mill was unique in that the chloride level in the sulfite acid and recovery system was higher than that of other sulfite mills. This high level resulted from the use of salt-water-borne logs for pulping in a closed acid-recovery system. The original designers of the Ketchikan pulp mill, recognizing that the salt-water-borne logs would bring into the pulping operation sodium chloride from the sea water, had incorporated a washing stage for the solid material recovered from the flue gases of the recovery furnaces. The investigation developed, however, that most of the sodium chloride was being recovered with the combustion gases as a fume and little was being precipitated and washed with the solid materials. The resultant high chloride level in the low *p*H acids contributed to the pit corrosion and stress corrosion of the stainless steels.

Investigation of the chemical and metallurgical properties of the stainless steels used in the construction of the Ketchikan mill indicated that many of the alloys were of substandard grade for the required service. The mill equipment was ordered in 1952 during the Korean crisis, when the molybdenum content of Type 316 stainless steel was limited to below 2.5% by the United States Government. Some of the Type 316 stainless steels which failed in service were found through chemical analysis to have molybdenum contents below the AISI specifications and others to have carbon contents over the maximum prescribed. In some services, even stainless steels which met the AISI specifications were too low in molybdenum content or too high in carbon content to resist the corrosive atmosphere.

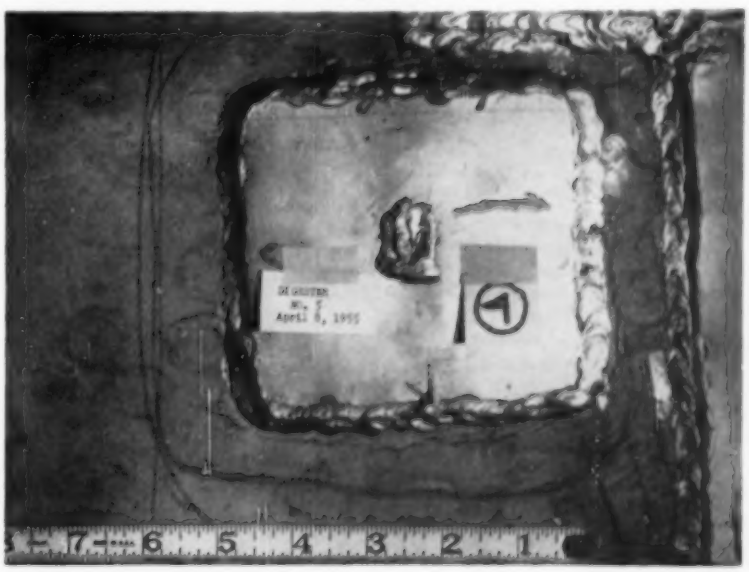
It was found also during this investigation that improper heat treatment, built-in stresses during fabrication, and improper design each contributed to the failure of the stainless steels through intergranular corrosion, pit corrosion, crevice corrosion, stress corrosion, and weld dilution when the stainless steels were exposed to the low *p*H and the moderately high temperatures (70 to 125° C.) of the spent sulfite liquors.

Corrosion

INTERGRANULAR

It is well known that the austenitic stainless steels are metallurgically unstable when heated in a temperature range of 350-800° C. When the alloys are exposed to this temperature range during stress relieving, heat treating, or welding they become susceptible to severe attack at the grain boundaries by even relatively minor corrosive media (*1*). This attack is referred to

Fig. 1. General intergranular corrosion and stress corrosion cracking in the Hastelloy F liner of the digester domes.



often as intergranular corrosion, an example of which is shown in Figure 1. One theory presented for the cause of intergranular failure is that exposure of the alloy to the above-temperature range causes the carbon to precipitate at the grain boundaries as a chromium carbide, depleting the chromium in the adjacent area. In a corrosive medium the grain boundaries are attacked and whole grains drop out, leaving a thinned, sugary-surfaced alloy. Earlier investigators believed that if the carbon content was as low as 0.07%, the Type 18-8 stainless steels would become free of intergranular attack (*2*). However, recent work has indicated that 0.03% C is the maximum allowable in these alloys in order to attain immunity to intergranular attack (*3*). While investigators at the Ketchikan mill were not able to verify whether 0.03 or 0.07% is the maximum carbon content allowable, all the samples of Type 316 stainless steel which failed intergranularly were found upon analysis to have 0.07% or higher carbon content.

Intergranular attack of the metal adjacent to the weld deposit will frequently take place after welding a stainless steel having a high carbon content. This area is heated by the welding operation into the sensitizing range allowing the carbides to precipitate, the amount of precipitation being dependent upon the time within the critical temperature range and the carbon content of the alloy. Resultant intergranular attack in this heat-affected zone is frequently called "weld decay" and, in many instances, will be associated with stress or fatigue corrosion. The combination of weld decay and stress corrosion cracking was frequently found at the Ketchikan mill in fabricated stainless steel tanks and piping. The practice of water quenching stainless steel welds regardless of the carbon content of the alloy has greatly reduced the frequency of these failures.

General intergranular corrosion was found to be serious in the domes of the digesters. The domes had been lined with panels of Hastelloy F,* whereas the barrels and the cones of the digesters had been lined with Type 316 ELC stainless steel (extra low carbon 0.03% max.). Hastelloy F had been used for the digester dome liner since it was felt that the moist acid vapors in the gas space would be more corrosive than the liquid acid contained in the barrel and the cone. The experimental tests conducted by the supplier had shown the high nickel alloy to be more resistant to acid vapor attack than the Type 316 stainless steel. Metallurgical analysis of an intergranularly attack specimen, however, showed that these dome liners had been subjected to a temperature range which sensitized the alloy. This occurred either during fabrication or field stress-relieving and resulted in the formation of a nonresistant precipitate in the grain boundaries.

The resultant intergranular attack caused irregular thinning of the panels and soon promoted stress corrosion cracking along the heat-affected zones of the weld seams. As a result, it became necessary to cover all the seams in the domes with strips of Hastelloy F to prevent leakage. In the severely attacked areas, the stress imparted by the welding cracked the irregularly thinned liner alongside the new strip repairs to the point where as much as 20% of the dome surface area was covered by repair strips before the cracking ceased. In areas of mild attack, grinding and polishing the granular surface retarded the recurrence of granulation and no further problems were encountered.

Cones of the digesters which had been lined with Type 316 ELC stainless steel also had a small amount of general intergranular attack. Analysis of the material from one of these attacked areas showed the alloy to have a carbon content of 0.07% rather than the 0.03% maximum allowed for ELC stainless steels and showed pronounced carbide precipitation at the grain boundaries. From the pattern of attack, it is believed that the stress-relieving operation had caused the carbide precipitation. Repair of these areas to prevent further granulation and leakage of acid was accomplished by overlaying the areas with strips of Type 316 ELC stainless steel.

PITTING

The frequency of pitting of the tubes in the heat exchangers associated with the multiple-effect evaporators in the recovery system of the spent sulfite liquors was severe during the first year of operation. In this period it was necessary to replace approximately 20% of the Type 316 stainless steel heater tubes in the first two heavy-liquor effects as a result of leakage caused by pitting. Many of the remaining 80% of the tubes were also severely attacked by pit corrosion, but were not replaced since the pits had not penetrated through the tube wall. This type of corrosion was severe also in the evaporator liquor piping, valves, pumps, and heater bodies associated with the first two effects.

During the course of this investigation, a survey of the literature on pit corrosion revealed that the frequency of pitting of stainless steels in an acid solution containing chlorides reaches a minimum when the solution *p*H is between 3.5 and 4.5, and that stainless steels containing 2.0 to 4.0% Mo will appreciably resist the tendency toward pitting when these alloys are used in acid solutions containing chlorides (*1a*). The investigation divulged that the spent sulfite liquors entering the evaporator bodies had a *p*H of less than 3.0. It was known that the chloride concentration of the spent liquors was considerably higher in the first two effects of the evaporator unit inasmuch as the chloride concentration increases as the solids concentration of the spent liquor is increased from approximately 13.0% in the entering feed liquor to 40.0 and 55.0% in the first two effects. Corrosion attack in this area was also accelerated since the first two effects are operated at a much higher temperature than the last four effects which are operated under a vacuum.

Heat analyses furnished by the supplier of the heater tubes disclosed that the molybdenum content of the original tubes ranged between 1.98 and 2.36%. Analyses of the tubes which failed through pitting showed that none of those tested had a molybdenum content of over 2.2%. Replacement tubes, having a molybdenum content of 2.27 and 2.47%, upon examination after sixteen months' service indicated that the pitting attack was continuing although at a considerably reduced rate, and replacement tubes having a molybdenum content of approximately 3.0% have shown an even greater resistance to pitting attack.

A striking illustration of the effect of molydenum content in Type 316 stainless steel with regard to pit corrosion resistance is shown in Figure 2. This pair of valve discs failed in approximately six months of service in concentrated spent sulfite liquor and were analyzed for molydenum content. The disc having a molybdenum content of 1.15% Mo was completely cratered with deep pits, while the second disc, having a molybdenum content of 2.15%, was only slightly pitted.

Experimental work in the laboratory, with the use of ionic potential measurements, indicated that the evaporator condensate was effective in passivating Type 316 stainless steels. Procedures were therefore initiated in plant operations for the passivation of newly installed evaporator tubes with the evaporator condensate before go-

* Trade mark of Haynes Stellite Corporation. Composition: Ni 44-47%; Co 2.50% max.; Cr 21-23%; C 0.08% max.; Mo 5.5-7.5%; Fe approx. 15%.



Fig. 2. Effect of molybdenum content in Type 316 stainless steel with regard to pit corrosion resistance. Disk on left, 2.15% Mo; disk on right, 1.15% Mo.

ing into spent-liquor service. Although this investigation did not determine the magnitude of improvement of corrosion resistance, experimental data recently reported in the literature has indicated that the resistance to pit corrosion may be improved as much as fifteen- to thirty-fold by proper passivation (*4*).

As a result of putting into operation the techniques developed by this investigation, it was possible to reduce the replacement of leaking evaporator tubes caused by pit corrosion from 20% during the first year to less than 2% in the succeeding years. The methods adopted were:

1. To buffer the incoming spent sulfite liquor to a pH between 3.5 and 4.0.
2. To install replacement tubes in the evaporator heaters having a minimum molybdenum content of 2.75%.
3. To passivate newly installed tubes with evaporator condensate.
4. To improve operations in such a way as to minimize the scaling of the evaporator tubes.

CREVICING

Crevice, contact, or concentration cell-type corrosion takes place when the corrosive medium is trapped or stagnant on the stainless steel surface. This type of corrosion had been prevalent in the flanges of piping, valves, and heaters used in the acid and recovery systems. A common type of flange used in the Ketchikan mill, as well as in most sulfite pulp mills, is the Van Stone flange, two variations of which are the formed and the fabricated slip-on type of Van Stone flange. Gaskets in these flanges were originally installed without a gasket-lubricating compound, allowing the acidic liquors to penetrate the gasket material and to set up concentration cells. The irregular-surfaced flanges resulting from this attack frequently leaked. In many instances where immediate leakage did not take place, stress-concentration centers were formed which led to eventual stress cracking of the flange. The fabricated slip-on type of Van Stone flange had an additional disadvantage in that the heat-affected zone of the weld was found to be extremely susceptible to corrosion and the attack rapidly thinned the flange metal; this thinning resulted in the failure of the flanges through stress cracking.

Corrective measures adopted at the Ketchikan mill have substantially reduced the failures from crevice corrosion in the stainless-steel-type flange joints. These measures include the use of heavy cast Van Stone flanges together with a gasket lubricant to seal the joints. Where pipe diameters are too large for cast flanges to be economically used, the mill is continuing to use a welded slip-on-type fabricated flange. When this type of flange is used, however, the stainless steel material is specified to be of extra-low carbon type and the welding is specified to be water quenched.

The tongue- and groove-type-flange joint which is commonly used in the manufacture of heat exchangers and of double-seating valves was also found to be susceptible to crevice-type corrosion. The crevice formed by the tongue and groove trapped acidic liquor which then attacked the metal above and below the gasket; this caused leakage. To eliminate this type of corrosion, the design of the flange of the double-seating valves has been changed to a male- and female-type-flange joint (Figure 3). In the case of heat-exchanger flanges, it has been necessary to remove the tongue, weld-overlay the groove, and finish the surfaces by grinding or machining to form flat-faced-flange joints.

Other instances of crevice corrosion occurred in localized areas throughout the mill wherein poor design and pinholes, slag-holes, or crack in the weldment allowed liquor to seep into voids. The stagnant pockets of liquor then set up concentration cells which continued until localized failure of the alloy was complete. These failures have been relatively minor and can be prevented through close supervision of design and welding techniques.

Fig. 4. Type 316 stainless steel Van Stone pipe flanges which failed as a result of crevice and stress corrosion.



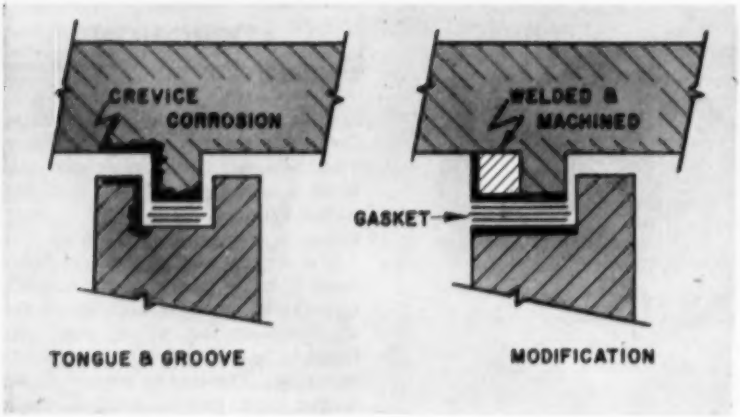


Fig. 3. Changes made to eliminate crevice corrosion in tongue and groove flange joints.

STRESS AND FATIGUE

Stress and fatigue corrosion differ in that the former is caused by static or internal stress and the latter is caused by cyclic stress; however, they are both being considered here as stress corrosion. The literature survey pointed out that chloride solutions, especially magnesium chloride solutions, are well known for their promotion of stress corrosion of stainless alloys and are commonly used in accelerated tests to determine the susceptibility of alloys to stress corrosion (*1b*). This explained many of the rapid failures of the stainless steels from stress corrosion at the Ketchikan mill. It was found also during the course of this investigation that stress corrosion usually occurs in conjunction with some other type of corrosion. When pitting, crevice corrosion, or intergranular attack occur, the metal surface becomes irregular from the attack. These chemically formed surface irregularities function in stressed sections as stress raisers of unusually high intensity and result in the failure of the alloy through stress cracking.

Stress corrosion in combination with intergranular attack was found in the Hastelloy F lined digester domes. The irregular surface resulting from the intergranular attack not only thinned the alloy but formed stress-concentration centers so that the cyclic stresses, imparted by the difference in thermal expansions of the Hastelloy F liner and the mild steel shell, caused stress-cracking failure of the stainless alloy, especially along the heat-affected zones of the welds (Figure 1). As mentioned previously, the method used to combat this type of attack was to cover the area with repair strips. These repairs were not completely satisfactory since liquor can collect in the void behind the strips and attack the mild steel. A Type 317 ELC stainless steel floating liner which lies up against the mild steel shell and which is free to expand with temperature has been used since to reline the digester domes. Operation for a year with this type of liner has shown no corrosive attack.

Stress corrosion occurred in the formed elbows of the lighter gauge Type 316 and 304 stainless steel piping. Stress cracks which normally occurred near or across welds resulted from the accumulated stresses of the forming operation, the welding, and finally from the continuous vibration in the piping. By the use of mitered elbows, heavier gauge stainless steel, and sturdier pipe hangers it has been possible to minimize this type of failure. Failures from the combination of stress and crevice corrosion in the Van Stone-type flanges (Figure 4) were also greatly decreased through improvements in the layout of pipe lines and the design of the flanges, such as the use of the heavier Van Stone cast flanges.

Weld Failure from Carbon Steel Dilution

When welding stainless steel to mild or carbon steel, the initial stainless weldment is normally diluted by approximately 30% (*5*). Subsequent overlays will approach progressively the original stainless steel welding rod composition, the number of overlays required before the stainless properties of the weld are retained depending on the rod and base-alloy compositions. If insufficient overlays are made, the diluted weldment will be susceptible to attack even in relatively mild corrosive media.

An example of where an insufficient amount of weldment had been laid down was the construction of the flanges on the heater bodies and piping of the evaporators in the spent sulfite recovery system. These flanges had been fabricated by welding a thin stainless steel face ring to a heavy mild steel backing ring and the flange surface was then machined. The stainless weldment had been sufficiently diluted by the mild steel backing ring to lose its corrosion resistance properties; this loss necessitated the replacement of approximately 20% of the flanges on the heaters and piping in the evaporator section due to leakage. The remainder of the flange welds are being slowly attacked and will have to be rebuilt or the flanges replaced in the near future.

Conclusions

The Ketchikan Pulp Company set up rigid specifications for the ordering of new and replacement equipment. For Type 316 stainless steel, the most commonly used alloy for sulfite acid service, the specifications are as follows:

1. Molybdenum content—2.75% minimum.
2. Carbon content—0.04 to 0.06% preferred, with a 0.07% maximum.
3. The alloy is to be fully annealed. If the alloy has been cold worked, it is to be reannealed followed by a water quench.
4. For fabricated sections it is stipulated that all welds are to be water quenched and, if it is known that the alloy is to be used in an extremely corrosive medium or in a vulnerable location, the extra-low carbon alloy is specified.

Acknowledgments

To the Crucible Steel Company of America and the Babcock and Wilcox Company for their assistance in this investigation acknowledgment is herewith made.

Literature Cited

1. Uhlig, H. H., ed. "Corrosion Handbook," 4th printing, p. 161, John Wiley & Sons, Inc., New York (1953).
1a. p. 170-73.
1b. p. 174.
2. Strauss, B., B. H. Schottky, and J. Hinnüber, "Die Carbid Ausscheidung Beim Gluhen Von Nichtrostenden Unmagnestichen Chromnickel Stahlm," *Ziet anorg. allgem. chem.*, **188**, p. 309-24 (1930).
3. Binder, W. O., C. M. Brown, and Russell Franks, *Trans. Am. Soc. Metals*, **41**, p. 1301-70 (1949).
4. Streichner, M. A., *J. Electrochem. Soc.*, **103**, No. 7, p. 375-90 (July, 1956).
5. Bystram, M. C. T., *Brit. Weld. J.*, **3**, p. 41-46 (February, 1956).

Presented at A.I.Ch.E. meeting, Seattle, Washington.

NUCLEAR SAFETY CONSIDERATIONS IN REPROCESSING PLANT DESIGN

Some of the nuclear safety aspects of the design and operation of reactor fuel separations plants are presented. The primary purpose is to acquaint those desirous of entering the spent reactor fuel processing business with some of the problems that must be considered in the design and operation of such a plant.

Norman Ketzlach

Hanford Laboratories Operation
General Electric Company
Richland, Washington

The principles of unit operations that apply to nonradioactive chemical separations apply equally well to plants processing reactor fuels, but the designer and operator of radiochemical plants have another factor with which to contend: the raw-material feed is radioactive and fissionable. This presents two new types of problem: protection of personnel from radiation and prevention of conditions that can lead to self-sustaining chain reactions. This paper will be concerned with the latter, namely, some of the design considerations necessary to ensure that no such criticality condition occurs in the chemical separations plants.

With the critical-mass information that exists, problems arising under many specific conditions can be solved realistically; however, it is difficult to write in a paper of this size a set of nuclear safety rules that apply to all plant-processing conditions. For reprocessing of spent reactor fuels where a great variety of techniques and conditions may be represented, over-all regulations are likely to be easily misapplied. Blind applications of general rules can work in two directions. Misapplication in one direction can lead to criticality accidents that are dangerous to both life and property. Misapplication in the opposite direction with insufficient attention to extenuating conditions may lead to unnecessary expense in both the construction and operation of large-volume processing plants. Therefore, it is necessary to understand the principles of reactor physics as well as the plant-processing conditions involved to ensure the proper application of these rules as well as to determine criticality conditions for process steps that cannot be covered by general rules.

Safety

Nuclear safety is accomplished by one of several methods: (1) making the process safe by geometry, (2) establishing batch limits on each process vessel, or (3) setting operating limits on solution composition. The method used depends on the plant capacity desired and on feasibility. Within a single plant all three methods may be used, each method being applied for most efficient plant operation of each process step. Application of these methods to the processing of spent reactor fuels will be illustrated by the following steps:

1. Storage and cooling of reactor fuels.
2. Dissolution of the fuel elements.
3. Separation of fissionable materials from fission products.
4. Separation of plutonium from uranium.
5. Preparation of plutonium and uranium for reuse.

Storage and Cooling of Reactor Fuels

In the storage and handling of natural uranium fuel elements, both unirradiated and irradiated, there are generally no criticality problems. In the handling of enriched fuel elements, however, storage of the elements is generally accomplished by limiting the number of elements per storage container and controlling the spacing between containers. For purposes of illustration, a 1.0% enriched U^{235} fuel element will be considered. These fuel elements will be solid cylinders having right circular cross-sectional areas. The following is based on theoretical calculations, which have been verified by experiment (*2, 3*), made for unirradiated elements of 1.0% enrichment as described above. A conservative correction was made for the fuel-element jacket that encased the experimental fuel elements. Figure 1 is a plot of the minimum critical mass for these fuel elements

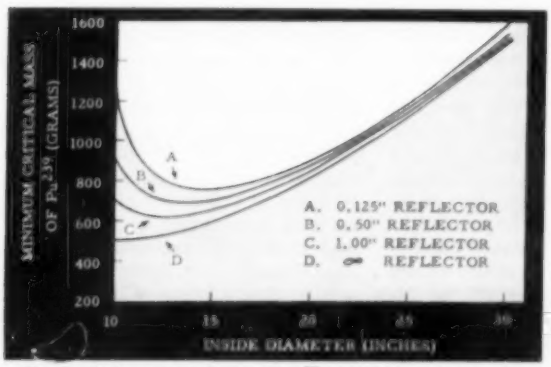


Fig. 3. Minimum critical mass of Pu^{239} vs. cylinder diameter for various equivalent reflector thicknesses.

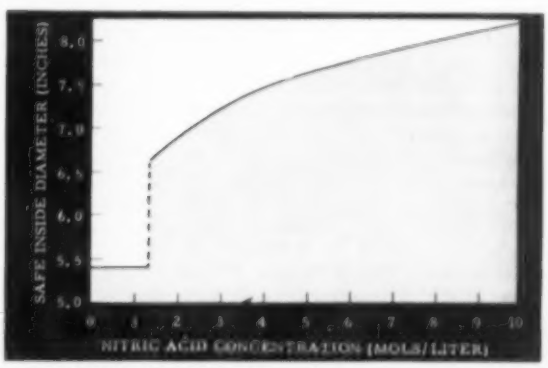


Fig. 5. Safe diameter vs. nitric acid concentration (plutonium nitrate solutions). Plutonium present as Pu^{239}.

vs. water-to-uranium volume ratio for fuel elements of different diameters. For each diameter there is an optimum water-to-uranium ratio for minimum critical mass, this ratio being different for each diameter element. Therefore, if the spacing between elements cannot be controlled, a safe number per storage container must be set which has a mass below the minimum critical mass for the specific diameter element under consideration. These curves, being based on unirradiated 1.0% enriched elements, should not be used for fuel elements of this enrichment after irradiation. To determine the minimum critical mass of these elements after irradiation, the reactor-power level to which these elements were subjected must be considered. For irradiated fuel elements, the plutonium isotopic content build-up as well as the uranium isotopic content must be considered.

Dissolution of the Fuel Elements

In the dissolving of reactor fuel elements, an additional problem must be considered that does not occur in the safe storage of fuel elements. In the dissolution step the fuel-element diameter is continuously being reduced as dissolution takes place. The effect that this has is illustrated in Figure 2, which has been based on unirradiated fuel elements of 1.0% U^{235} enrichment. Figure 2 is a plot of the minimum critical mass as a function of fuel-element diameter. Therefore, if the diameter of the original fuel element is greater than that for minimum critical mass, the minimum critical mass for the particular enrichment under consideration must be used in establishing safe batch limits. Figure 2, as well as Figure 1, is based on uranium-water systems. If nitric acid is being used as the dissolving agent and a minimum nitric acid acidity can always be guaranteed, greater minimum critical masses would result. The presence of nitric acid is equivalent to adding a neutron poison as well as to decreasing the hydrogen concentration of the moderator in the dissolver system. However, if another dissolving agent such as hydrofluoric acid is used, the minimum critical mass may not be much different from that in the water system, because of the very small neutron-absorption cross section of the fluorine in the hydrofluoric acid compared with the nitrogen in the nitric acid system. As dissolution takes place and some of the uranium goes into solution, the minimum critical mass of the system is increased, such increase due primarily to the decrease in resonance-escape probability for U^{238}.

In the dissolution of irradiated natural uranium there are generally no criticality problems involved as was found to be the case in the storage and handling of these fuel elements. Where criticality is not a problem, the pros and cons of continuous dissolvers vs. batch-type dissolvers will be the same as for other types of dissolution processes. For the processing of enriched fuel elements, however, there are additional factors in favor of continuous dissolvers. Before a new charge can be made in a batch dissolver, the dissolver must be empty; otherwise it is difficult to determine an allowable batch size without knowing the size of the heel remaining in the dissolver from the previous dissolution. It would be necessary, therefore, to lengthen the batch-dissolution time until complete dissolution is attained. This greatly limits plant capacity because the rate of dissolution is a function of both acid and metal concentrations. Higher dissolution rates are attained with larger masses of metal for the same acid concentration. If it is desired to process both natural and enriched uranium simultaneously and in the same dissolver, the batch size for the enriched fuel elements may be reduced by a factor greater than two in the presence of an arbitrary amount of natural uranium. However, mixing enriched uranium with natural uranium may reduce the resale value of the recovered uranium.

For a continuous dissolver processing a 1.0% enriched uranium (based on unirradiated fuel elements), the safe diameter, for a single water-reflected dissolver for a uranium-water system, is about 22 in. Of course, if a minimum nitric acid acidity can be guaranteed at all times, this diameter could be increased. For larger enrichments, smaller diameters are required. Since continuous dissolver capacity is a function of dissolver cross section, which in turn is a function of enrichment, one must consider the range of enrichments to be processed and determine whether it is more economical to process the entire range of enrichments in one dissolver or to have dissolvers of several sizes, each to process a single enrichment or range of enrichments.

Separation of Fissionable Material from Fission Products

After the dissolution step the separations plant is concerned with solution handling. The solution now contains fission products, uranium, and plutonium. With this type of solution, safety may be ensured by composition, batch size, or geometry. If precipitation can be precluded, the concentration of fissionable material (U^{235} plus Pu^{239}) can be limited by the more reactive constituent, plutonium. In this case 6 g./liter is a safe concentration for the total fissionable material. Safety factors inherent in such a system are acid- and fission-product concentration. If a precipitate cannot be precluded, nuclear safety can be established by maintaining a maximum ratio between fissionable material (U^{235} plus Pu^{239}) and U^{238}. The safe ratio of this system in water is a function of the enrichment of the original fuel elements as well as the pile exposure conditions. Safe diameters for single vessels containing this solution will be greater than the diameter of the dissolver for fuel elements of the same enrichment and for the case considered above may be as high as 30 in. After the fission

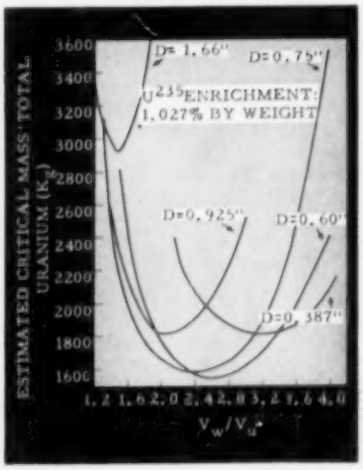


Fig. 1. Estimated critical mass total uranium vs. water to uranium ratio.

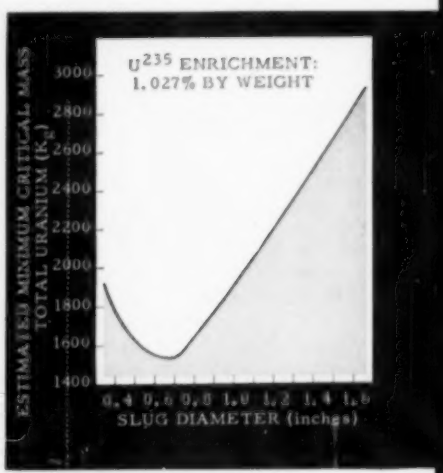


Fig. 2. Estimated minimum critical mass total uranium vs. slug diameter.

products have been removed from the fissionable material, the same methods can be used to guarantee plant nuclear safety. Now, however, the safety factor of having fission products (neutron poisons) present no longer exists.

Separation of Plutonium from Uranium

When the separation of plutonium from uranium is attained, safety of the plutonium, due to the presence of U^{238}, no longer exists. The two streams to be considered are now a plutonium solution and a uranium solution. The nuclear safety of the uranium solution is a function of the U^{235} to U^{238} ratio. Experimental results on U^{235} solutions have already been reported in the unclassified literature (*1*). Experimental data with uranium systems of different enrichments have also been performed at the Oak Ridge National Laboratories. The nuclear safety of plutonium solutions will be examined here in more detail, the study being based on experiments performed at the Hanford Atomic Products Operation (*4*). A safe design can be based on the same considerations as above: safety by batch size, composition, and geometry. One other factor will also be considered, namely, the effect of neutron reflectors on criticality. In the previous processing steps completely water-tamped systems were assumed. Before the separation of fission products, the plant structure and neutron reflectors (vessel walls, structural supports, concrete walls, etc.) are generally so great as to be equivalent to complete water reflection.

Figures are presented to illustrate how these variables affect the nuclear safety of separations plants. These curves are based on all the plutonium being present as Pu^{239}.

Figure 3 is a plot of minimum critical mass of plutonium vs. cylinder diameter as a function of equivalent reflector (vessel walls, structural supports, framework, concrete walls, presence of personnel, etc.) thicknesses. These calculated values for minimum critical mass are based on plutonium-water systems. As stated above, if the minimum acidity could be guaranteed, the critical parameters would not be so restrictive. However, in a number of process steps neither a minimum acidity nor absence of precipitation can be guaranteed. It is seen that reflector thickness is more important for small-diameter vessels than for those of large diameters.

Figure 4 gives the estimated minimum critical mass for effectively water-tamped cylinders of smaller diameters. The curve is not extended to diameters smaller than 6 in. because of the larger uncertainties in the calculations for vessels of smaller diameter. This curve shows the very rapid rise in minimum critical mass for vessels of smaller diameter, which approaches infinity as the vessel diameter approaches a safe diameter for plutonium solutions.

Figure 5 is a plot of safe diameter for plutonium solutions as a function of nitric acid acidity. A safe diameter vessel for plutonium solutions is one that cannot be made critical no matter how much plutonium solution is placed in an infinitely tall vessel having this diameter. The curve is broken for acidities below about 1.3 M nitric acid as plutonium nitrate in high concentrations begins to decompose below this acidity. Under these conditions the safe diameter is about 5.4 in. for plutonium concentrations below 500 g./liter "solution" and may be as low as 4.5 in. for somewhat higher concentrations. This uncertainty is due to lack of experimental information on plutonium "solutions" of this type.

When plutonium nitrate in solution begins to decompose, what has been referred to as a *plutonium polymer* is believed to be formed. This has been assumed to have the composition $PuO_2 \cdot (H_2O)_{18}$. Figure 6 is a plot of plutonium concentration vs. nitric acid acidity showing the the region in which this polymer is formed (*5*). It appears that there is no polymer formation for acidities greater than 1.3 M nitric acid.

Figure 7 is a plot of safe diameter as a function of equivalent reflector thickness. For "bare" vessels (no reflector) the safe diameter approaches 8 in. For very thick equivalent reflectors, the safe diameter approaches 5.4 in. The same restrictions on plutonium concentration as described above should be applied to these safe diameters.

Figure 8 is a plot of critical-solution height for optimum moderation as a function of vessel diameter for effectively water-reflected vessels. From this curve the critical volume as a function of vessel diameter can readily be calculated. For plutonium solutions of concentration greater than about 500 g./liter, the same uncertainties exist as described above.

Figure 9 is a plot of critical concentration of plutonium as a function of vessel diameter for infinitely tall water-tamped vessels. Calculations upon which this curve is based did not give credit for nitrate ion that may be present. It is therefore conservative for actual solutions of plutonium nitrate in the presence of excess nitric acid.

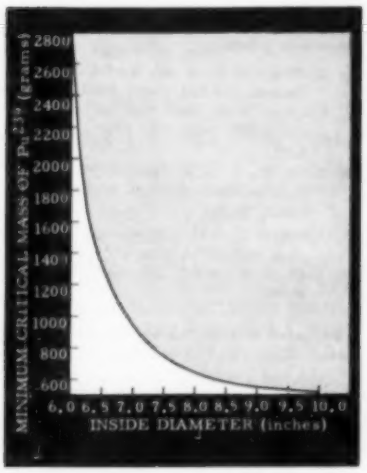


Fig. 4. Minimum critical mass of Pu^{239} vs. cylinder diameter (for water-tamped cylinders).

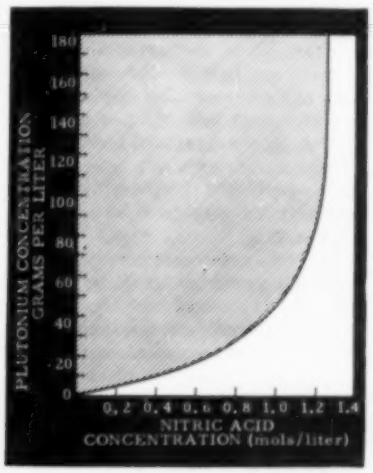


Fig. 6. Region of plutonium polymer formation.

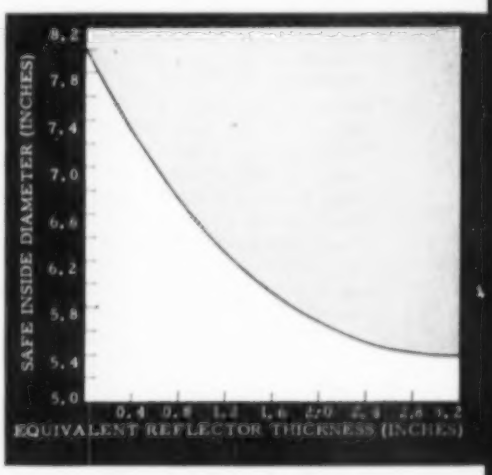


Fig. 7. Safe diameter vs. reflector thickness.

Application of Nuclear Safety Rules

In the application of criticality data to the different steps of a separations plant, the following factors must be considered. Whether safety is determined by batch limitations, geometry, or solution concentration, the effect of reflectors must be carefully considered. Where no contact-maintenance problems are involved, reflectors may be taken into account more closely in vessel design. However, where contact maintenance may be involved, a more

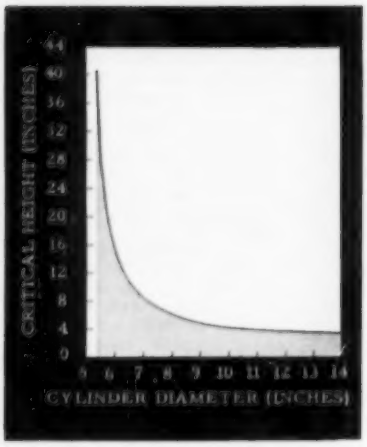


Fig. 8. Critical solution height for water-tamped cylinders.

liberal consideration of neutron reflectors is necessary. Allowance must be made for maintenance personnel's approaching plutonium-solution-bearing vessels, as they add more neutron reflection to the vessel the closer they approach it. One very important factor which has not been considered above is the effect of interaction between vessels. In this discussion vessels were considered as isolated vessels in which there are no vessel inlets into the side. Side inlets have the effect of increasing the effective vessel diameter in the same way that interaction with other vessels does. In actual practice, it requires too much space to build a plant in which there is no interaction between vessels. Among the factors to be considered for interaction between vessels are vessel sizes, separation between vessels, neutron reflectors between vessels, and solution composition. This subject is beyond the scope of this paper. However, the following generalities will be made: (1) for a given vessel diameter interaction varies inversely as a function of separation; (2) for a given vessel diameter and given spacing, interaction varies inversely as a function of the amount of neutron reflectors between vessels; and (3) for a given spacing, interaction varies directly as a function of diameter.

In operating by batch limitations, the following factors should be considered: accuracy of analyses, efficiency of process control, and the possibility of double batching. By *double batching* is meant the possibility of making a single operating error and adding a solution batch to a vessel already containing one. Where double batching is a possibility, the batch size should be less than half the estimated minimum critical mass after the operating and analytical uncertainties are considered. In the control of process steps by concentration, where precipitation can be precluded, 75% of the critical concentration may be used as a safe concentration.

For safety by geometry, the data presented above for infinitely tall vessels may be considered safe for plutonium concentrations less than 500 g./liter. For aqueous solutions of somewhat higher concentration, the minimum safe diameter may be about 15% less.

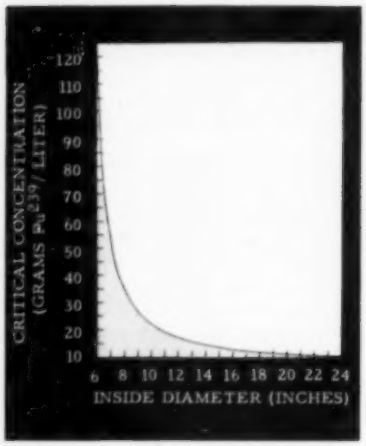


Fig. 9. Critical concentration of Pu^{239} for water-tamped cylinders.

Literature Cited

1. Callihan, A. D., J. W. Morfitt, and J. T. Thomas, *UN-834* (June, 1955).
2. Clayton, E. D., and Herschel Neumann, *HW-40930* (Jan. 16, 1956). (Declassified).
3. Kouts, H., J. G. A. Price, K. W. Downes, Rudolph Sher, and V. J. Walsh, *UN-600* (June, 1955).
4. Kruesi, F. E., J. O. Erkman, and D. D. Lanning, *HW-24514* (May 19, 1952), secret.
5. Pugh, R. A., *HW-32100* (April 28, 1954), secret.

Presented at 1957 Nuclear Engineering and Science Congress, Philadelphia, Pa.

techniques

with radioisotopes

Condensed from AEC publication on Industrial Uses of Radioisotopes.

MEASURING CATALYST CIRCULATION TIME

In petroleum cracking processes one of the requirements for the production of gasoline to specifications is the maintenance of the proper recirculation rate of the catalyst. Because refining operations are carried out at high temperatures and pressures in a closed system, it is usually difficult to measure the rate of catalyst flow with sufficient accuracy.

A large West Coast refinery has tagged some of the catalyst beads (about 1 or 2 in 10 million) with radioactive Zr-95 (half-life 65 days; beta energy 0.4 mev; gamma energy 0.71 mev) and measures the gamma radiation through the walls of the reactor to obtain the circulation rate directly.

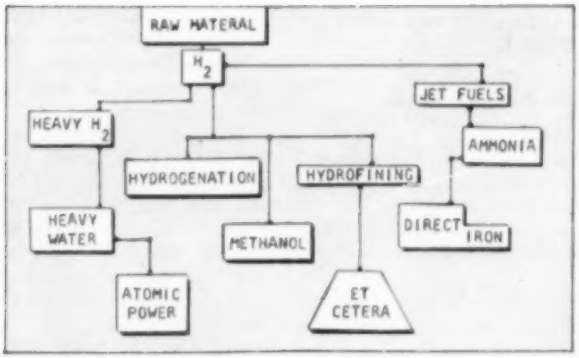
In practice, the measurement and computations are made automatically and the flow rate is recorded on a strip-chart. A pre-set flow rate can be maintained automatically through the catalyst chamber.

CONTROLLING OIL WELL ACIDIZING

To restore the porosity of oil-bearing formations, wells are often treated with 15% hydrochloric acid under pressure as high as 2,000 lb./sq.in. It is necessary to control the position of the acid in the well accurately to avoid wasting most of the acid on unproductive limestone formations.

A new method, now in use in the oil fields of Kansas and Oklahoma, involves the use of radioactive iodine (half-life 8 days; beta energy 0.3 and 0.6 mev; gamma energy 0.6 and 0.3 mev) which is added to the hydrochloric acid in quantities of 0.5 millicuries per 1,000 gallons. The position of the acid-oil interface is controlled by the response of a Geiger counter lowered into the inner tubing at the desired level.

This system is replacing older methods using electrical conductivity, etc., which usually required removal of the inner tubing and which always presented the possibility of a mishap.



WHICH WAY TO HYDROGEN?

A. G. Eickmeyer * | Consulting Engineer, Kansas City, Missouri

New processes based on hydrogen, still in the developmental stage, must be viewed in the light of experience with existing hydrogen uses. The author discusses, in a broad and exploratory way, present hydrogen production methods in order to indicate where chemical engineering ingenuity can lead the way in developing process performance and equipment specifications for the future.

Direct iron processes which would supplement or by-pass the costly blast furnace have caught the fancy of steel makers (*1*). Most of the direct iron methods under consideration would use vast quantities of hydrogen. Other methods would use natural gas directly, with hydrogen being generated in place. In either case, finely divided iron ore would be reduced to powdered iron in a fluidized bed.

The impact which successful commercialization of direct iron would have on the steel industry needs no elaboration. Steel would no longer be dependent upon coking coals, but could flourish wherever iron ore, gas or oil, and a steel market come together—in Texas, for example.

The Cyclosteel process, recently publicized by the British (*2*), would use powdered iron ore, powdered coal, and oxygen, and would yield molten slag and steel. However, the British are, quite properly, cautious about their claims for the immediate workability of the Cyclosteel process.

Producing the Hydrogen

In view of these and other developments, it is apropos to discuss, in a general way, the selection of a process for the manufacture of hydrogen, which is a major cost item in the direct iron process.

Every chemical engineer recognizes the technical importance of hydrogen and also the fact that it may be produced in any of several ways, all of which are used commercially. The more important methods are reforming with steam, partial combustion with oxygen, electrolysis, and purification of by-product hydrogen. The big question is, "Which is the best way to produce hydrogen for a specific case?" Our final goal—direct iron, ammonia, methanol, hydrodesulfurization, or high energy fuels—may hold our attention so closely that we lose sight of the fact that in order to get there, we must first choose our route to hydrogen.

PROCESS EVALUATION

The most suitable route for a specific case depends upon many factors. Since the economic desirability or even the success or failure of a new project may depend upon the route selected, another challenging question arises: "Can a rigorous, unbiased evaluation be made of the various routes as they apply to the case at hand?" The answer is not easy. The experience of competent engineers within a given company may not encompass all the alternates. A fair comparison must be made on a uniform basis but different engineers will still make different assumptions when starting to design a process. While each assumption may be reasonable, the point is that the bases are not identical, and the differences may affect all the design calculations.

It is easy to say, "Let's write a set of specifications and have everyone adhere to them!" but we must proceed cautiously, particularly in the development of a process. A specification may be so drawn as to be advantageous to one process while placing an unnecessary hardship upon another, thus unintentionally affecting the process economics to surprising degree.

A recent illustration of this is in the specifications for a methanol plant which called for 0.3 per cent residual methane in the hydrogen-rich reformed gas. The really basic question was, "At what pressure should the reformer be operated in order to minimize the over-all cost, including costly compression of synthesis gas to the 5,000-lb. synthesis loop?" As reformer pressure is increased, two things happen: first, the power for compression declines because of higher suction pressure to the compressor; second, the higher residual methane content requires a greater purge rate, and hence more power because of the larger volume of gas compressed. Pressure reforming has been used in a number of recent ammonia plants where a secondary reformer cleans up the residual methane by partial combustion with air. However, in methanol plants (which cannot tolerate the nitrogen in air), reformers had not been designed to operate at any substantial pressure. But this was no reason to believe that it would not be possible with the presently available high-temperature alloys for the reformer tubes. Therefore, an objective and thorough-going study was made on a rigorously uniform basis so far as the critical high-temperature alloys were concerned, which permitted the residual methane to fall where it might. Provided that careful attention be given to the size and design of the furnace, pressure reforming was found to be definitely desirable and, as a matter of fact, conventional low-pressure practice would have required about 50 per cent more power for compression.

* Mr. Eickmeyer was formerly assistant manager of the Petroleum and Chemical Division, J. F. Pritchard & Company, Kansas City, Missouri.

The power saved would be enough to keep a commercial airliner aloft continuously—approximately 87 million passenger miles each year! This is equivalent to one passenger circling the earth ten times each day.

The investment and operating costs were reduced not only because of the power saving, but also because of the process latent heat recovery, which becomes practical with pressure reforming. On the assumption that the cost of the natural gas raw material is comparable to that in other locations, this new plant should be able to produce methanol at a lower cost than any existing facility. If the original specifications on the rich gas. Other important factors are listed in Table 1.

Table 1.—Checklist for Project Planning

I. End Product.

II. Plant Location with respect to Raw Materials and Markets.

III. Quantity, Quality, and Pressure Requirements.
- A. Variation of plant investment with size.
- B. Purity and effect of impurities.
- C. Cost of compressing a low pressure gas.

IV. Local Cost of Raw Materials and Utilities.
- A. Availability.
- B. Reserves.
- C. Cost trends.

V. Stream factor desired.
- A. Plant investment.
- B. Complexity of over-all plant.
- C. Cost of downtime.

VI. Chemical composition of Raw Materials and of Products.
- A. Elemental material balance.
- B. Cost of eliminating undesired components.

VII. Competitive Processes.

VIII. Process Integration.
- A. Internal integration.
  1. Use of process waste heat for hydrogen purification.
  2. Hydrogen from petroleum catalytic reforming used for hydrodesulfurization or hydrogenation of heavy ends.
  3. Use of ammonia plant by-product CO_2 for making urea.
  4. Recovery of heavy hydrogen and heavy water. (?)
- B. External integration.
  1. Use of by-product hydrogen from petroleum catalytic reforming as feed to an ammonia plant.

IX. Commercial Integration.
- A. Internal.
- B. External.

residual methane had been adhered to, the costs would have been considerably higher. The lesson to be learned from this example is that the engineer must be imaginative in his specifications in order to encourage the process designer to be creative.

Incidentally, this development in synthetic methanol portends the reevaluation of the reforming process for production of hydrogen for other purposes.

The foregoing example illustrates just one of the factors to be considered in a carefully planned project which would use hydrogen or a hydrogen-

Checklist for Project Planning

Although the table is incomplete, it serves as a check list for hydrogen and other processes. The first four factors are well recognized and need no further elaboration. The last five factors are more elusive and are sometimes overlooked.

The greater the investment, the more important stream factor becomes. Unfortunately, the tendency toward greater complexity increases the likelihood of costly downtime. Designers should take pains, not only in preparing the flow sheets, but also in spelling out the equipment, to insure the securing of high quality materials and mechanical design suitable to the process. Actually, from a practical standpoint, a process designer should be thoroughly familiar with available mechanical equipment and also the operating problems. Unsuitable pumps have been known to shut down multimillion dollar plants!

If only hydrogen is wanted, the most suitable raw material, as regards chemical composition, would be pure hydrogen. Since nature isn't that cooperative, the next best source would be a material of high hydrogen content, such as natural gas. This is of course oversimplified, since energy balances as well as material balances are important.

Consideration of the first six factors in Table 1 will usually permit us to narrow the field down to two competitive processes, and sometimes to the one most suitable for the specific job.

Some thought should be given at this point to potential process integration which might improve the economics of the project. One or the other process may be better suited to integration. Process integration has been broken down into *internal* and *external* integration. Internal process integration may be defined as a combination of process steps, usually within the over-all process, which are naturally compatible from an operational and a long-range economic standpoint. External process integration involves tying together and rendering interdependent either incompatible process steps or the manufacture of poorly related products having a long range possibility of going their separate ways. Examples of each type are listed. Naturally, the internal type is desirable, but it is necessary to proceed cautiously with the external type. To expand on the example of using by-product hydrogen from an oil refinery to make ammonia, it is easy to imagine what would happen if the fuel economy of gas turbines were greatly improved by the development of a superalloy for turbine buckets, making such an engine practical for automobiles: with less demand for high octane gasoline and less reason to operate a catalytic reformer, what would we do with the ammonia plant?

Again, with reference to process integration, some items, such as heavy hydrogen, are difficult to classify, and may depend upon the type of process used. However, at $28/lb. of heavy water, which is equivalent to $140/lb. of heavy hydrogen, freight is no problem!

Regarding commercial integration, analogies can be drawn to the two types of process integration. Some companies indulging in too much external integration, for instance, have found themselves in the regrettable position of competing with their customers.

Literature Cited

1. Von Deusen, E. L., *Fortune*, p. 164-167 ff. (October, 1956).
2. *Chem. Week*, p. 94-96. (January 26, 1957).

Presented at A.I.Ch.E. meeting, Kansas City, Missouri.


D
Check on Syloids by Davison
✓ Flatting agent for vinyls, lacquers and varnishes
✓ Thickening agent for resins and inks
✓ Reinforcing agent for adhesives
✓ Anti-caking agent
✓ Anti-gassing agent for metallic paints
✓ Ink offset preventative
✓ Anti-blocking agent
For more information write today
Progress Through Chemistry
DAVISON CHEMICAL COMPANY
Division of W. R. Grace & Co.
Baltimore 3, Maryland
Sales Offices: Baltimore, Md.; Chicago, Ill.; Columbus, Ohio; San Francisco, Calif.; Houston, Texas; New York, N. Y.
Producers of: Catalysts, Inorganic Acids, Superphosphates, Triple Superphosphates, Phosphate Rock, Silica Gels, Silicofluorides, Rare Earths and Thorium. Sole Producers of DAVCO® Granulated Fertilizers.
SYLOID 244
SYLOID AL-1
SYLOID 162
SYLOID 308

WYANDOTTE, DIAMOND EXPAND CHLOR-CAUSTIC PRODUCTION

Major chlorine-caustic expansions demonstrate some of the latest thinking about when to use diaphragm versus mercury cells.

The $20 million chlorine-caustic plant of Wyandotte, now under construction at Geismar, La., will produce some 300 tons a day of chlorine, will increase Wyandotte's chlorine-caustic capacity by nearly 60% when it goes on-stream in late 1958, will be one of the largest installations of its type in the country.

Diamond's expansion of its Deer Park plant, on-stream early this year, increased chlorine-caustic soda production some 40%, which meant an additional 200 tons of chlorine a day.

Highlight: The Wyandotte expansion will be made with the installation of 300 Diamond Alkali 30,000 ampere rectangular diaphragm cells of an advanced design, while Diamond's own expansion was made with 120,000 ampere mercury cells, largest of their type in the world, and which are not manufactured by Diamond.

The story behind this unusual state of affairs goes deep into the engineering of the chlorine-caustic soda industry.

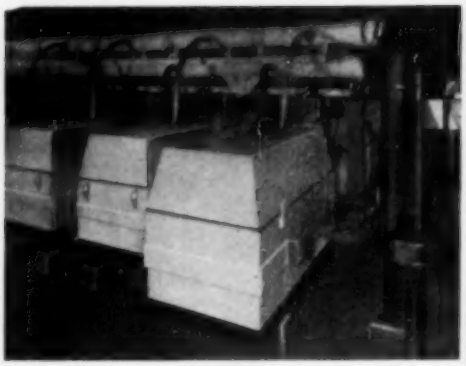
Diaphragm-Mercury in Tandem

Diamond, at its Deer Park installation, already had a large number of its own 20,000 ampere diaphragm cells. When the time came for expansion Diamond decided on the giant mercury cells from another company rather than more of its own cells.

Reason: Diamond engineers are convinced that the ideal chlorine-caustic soda installation contains both diaphragm and mercury cells.

Why this should be derives from the characteristics and economics of the two cells. The diaphragm cell is fed with brine, either made-up from solid salt or obtained directly from brine wells. The brine must be purified but not to the same high degree as the brine going into a mercury cell. Normally, a mercury cell * starts with pure water and highly pure solid salt, does not use brine from wells. The product of the mercury cell is pure caustic (rayon grade comes direct from the mercury cell), and a brine of low concentration which is recycled, brought up to full concentration by the addition of pure solid salt. The product of the diaphragm cell is a caustic

(*Continued on page 54*)

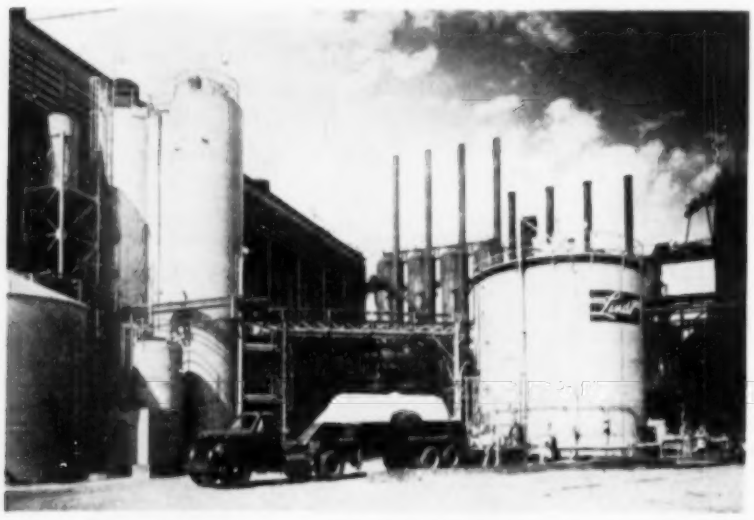


In the foreground is one of Diamond's new 30,000 ampere diaphragm chlorine-caustic soda cells, 300 of which will be installed at the new Wyandotte plant at Geismar, La. The new cell is contrasted to the smaller 20,000 ampere Diamond cells behind it which are installed at Diamond's own Deer Park plant together with new mercury cells.

* For a full treatment of mercury cells see "Horizontal and Vertical Mercury Cell Development in Europe and the United States," H. A. Sommers, Air Products Co., Allentown, Pa., which will appear in the August issue of *CEP*.

"PRIVATE" OXYGEN PLANT BUILT BY LINDE AT U. S. STEEL PLANT

The world's largest single unit oxygen plant for steel mill services has just gone on-stream, is the latest of Linde Company's (Union Carbide) "private" oxygen plants built to serve one particular company, located on or near the consumer's plant, but owned and operated by Linde.

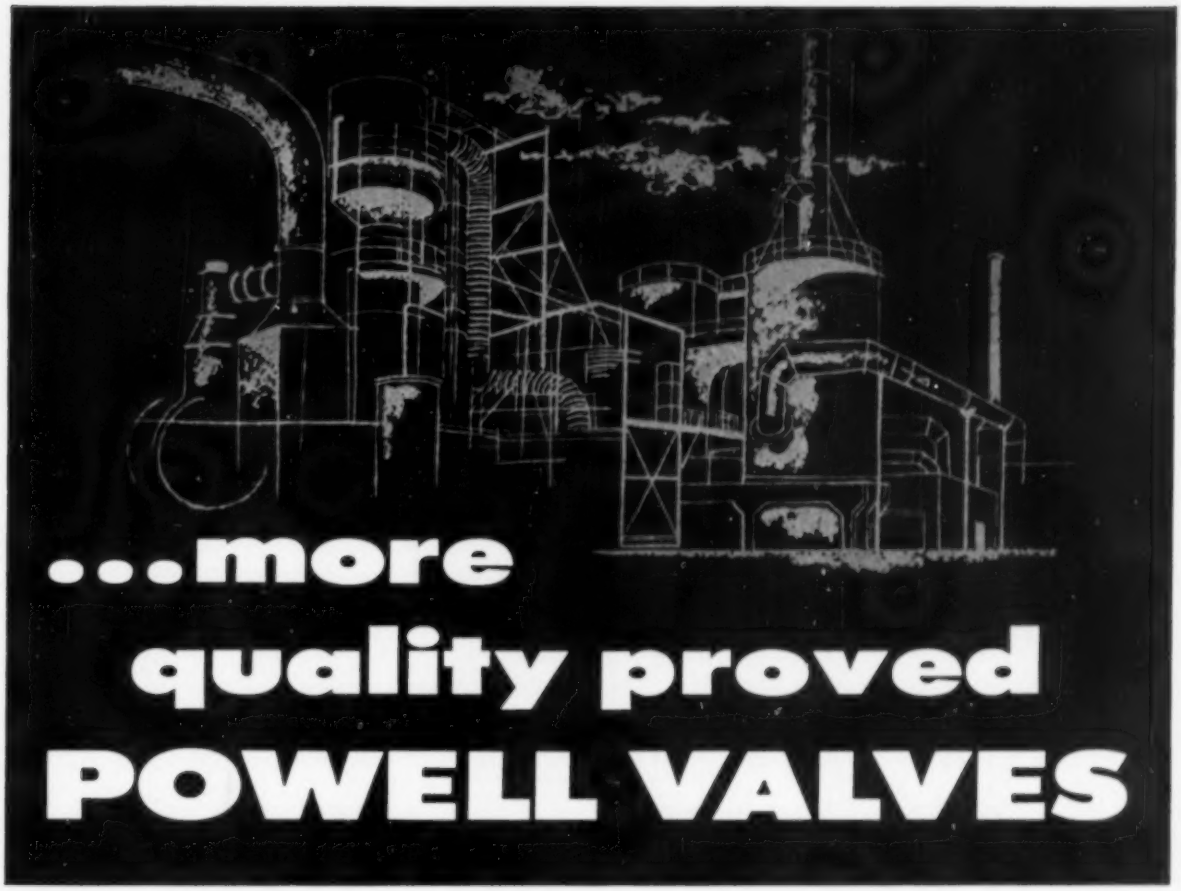


Tank truck at the new "captive" oxygen plant built by Linde Company (Union Carbide) at the Duquesne Works of U. S. Steel.

The new unit, rated at 500 tons of oxygen a day, is located on the site of U. S. Steel's Duquesne, Pa., Works.

About 90% of the oxygen produced is used to increase output and reduce fuel consumption in the Duquesne Works' ferromanganese blast furnaces. Actual output of the Linde plant is 430,000 cu.ft. an hour of 95% pure oxygen directly into pipelines to the two ferromanganese blast furnaces; an initial delivery rate of 42,000 cu.ft of 99.5% pure oxygen an hour to pipelines servicing electric furnaces, scarfing machines, etc.; and a stream of liquid oxygen for stand-by storage. A 15 hour reserve in case of shutdowns is provided, is built up from the unit's liquid oxygen stream to back up the low purity supply. The high purity supply is backed up by Linde's standard system of tank car or tank truck shipments from its nation-wide system of liquid oxygen plants.

Begun shortly after World War II, Linde's "captive" plants program has grown rapidly in recent years, units operating or being built range in capacity from 10 tons to thousands of tons a day. Linde builds the plants, owns them, runs them, maintains them, and contracts to sell the oxygen as needed.



...more quality proved POWELL VALVES

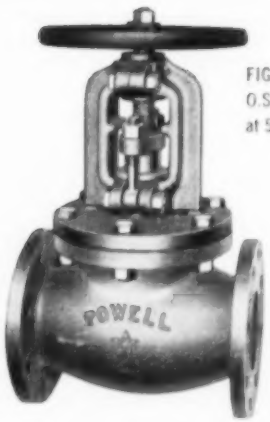


FIG. 2429—Large Size Stainless Steel O.S.&Y. Globe Valve for 150 Pounds W.P. at 500 F. or 230 W.P. at 100 F.

FIG. 1314A—1500-Pound Integral Bonnet Stainless Steel "Y" Valve.



FIG. 2342—Stainless Steel Bolted Cap Swing Check Valve for 150 Pounds W.P.



FIG. 2453SG—Stainless Steel O.S.&Y. Gate Valve for 150 Pounds W.P.



Designed for long life, designed for dependable service

Consult your Powell Valve distributor for all the facts about quality proved bronze, iron, steel and corrosion-resistant valves. For every flow problem . . . there is a Powell Valve to solve it.

THE WM. POWELL COMPANY, CINCINNATI 22, OHIO . . . 111th YEAR



Heliflow® Excels Any Other Heat Exchanger

This has been proven in virtually every job—and it's a "bearcat" for the real tough ones.

May we ask you just a few questions concerning your next heat exchanger job?

Do you have high operating pressures?

Are you pinched for installation space?

Do you have a severe temperature condition—thermal shock?

Do you require close temperature approach at both ends?

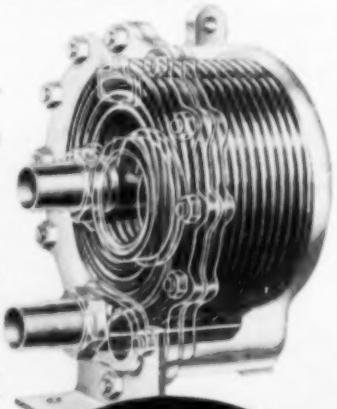
Is costly alloy construction required?

Is absolute mechanical dependability a "must"?

Is minimum liquid volume advantageous to you?

Would you prefer to condense and sub-cool in one shell?

Does shipment from stock or, in any event, quick shipment interest you?



We don't have to ask if you are concerned with low cost performance and handling more BTUs for your dollar—certainly Heliflow does all of this but, again, for the real tough jobs you will find Heliflow the optimum choice . . . indeed, real Thermal Magic.

Graham

GRAHAM MANUFACTURING CO., INC.
415 LEXINGTON AVENUE, NEW YORK 17, N. Y.
Offices in principal cities and Canada

CHLOR-CAUSTIC

(*Continued from page 52*)

liquor containing a high percentage of salt. This salt is removed during the caustic evaporation step, giving a pure solid salt. This solid salt can be used to make up brine for feeding the diaphragm cell again, *but it is pure enough to be used for a mercury cell with a minimum of brine treatment.*

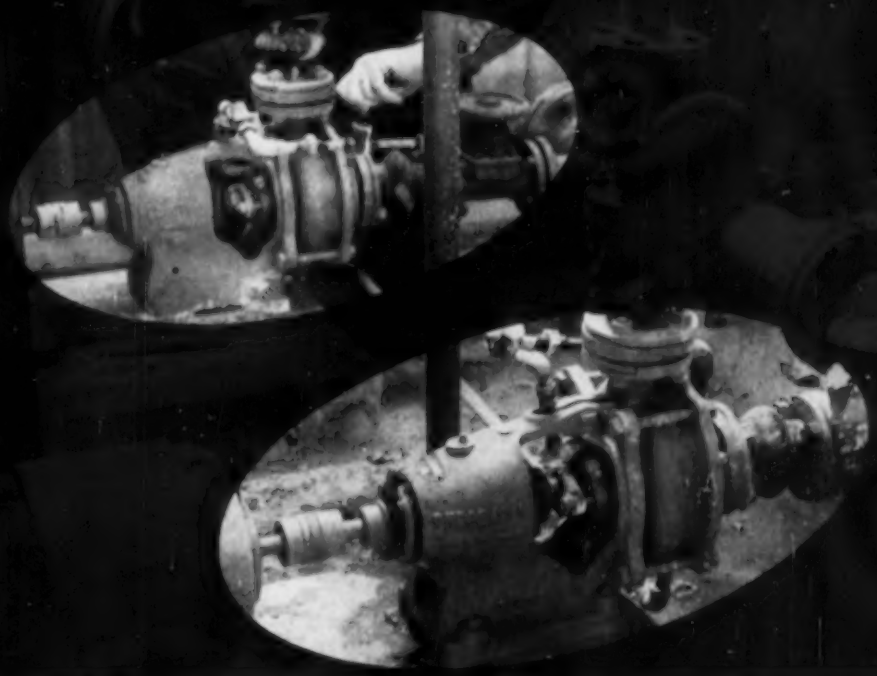
Crux of the efficiency of the tandem diaphragm-mercury cell arrangement is that by operating the cells in the same plant, the solid salt produced by the diaphragm cell can be used to feed the mercury cell and materially reduce brine treating costs. Also, if, as is the case at Diamond's Deer Park plant, the raw material can be produced by "brining" operations in wells rather than by the more expensive mining of solid salt, operating both cells in the same plant, and using the solid salt from the diaphragm cell in the mercury cell, will materially reduce the overall cost of the salt. The need to buy solid salt, or to put the brine from wells through an extra evaporation step to produce the needed high purity solid salt for the mercury cell, is overcome.

Obviously, a great part of the decision as to which cell will be used depends on the grade of caustic desired, since the mercury cell produces a superior grade. If a directly-produced rayon grade caustic is wanted, then the mercury cell is best. If not, then the diaphragm cell is more practical, according to Diamond, particularly if the raw material can be brine from wells.

The Wyandotte installation will be the first large-scale use of the new 30,000 ampere Diamond cell (this cell is similar to the Hooker diaphragm cell, certain patent differences exist), and Diamond will provide engineering know-how, design, assembly, and operational data. Advantages claimed for Diamond's new cell include: improved power efficiency; improved cell renewal techniques; low hydrogen content in the chlorine cell gas and low chlorate contamination of the cell liquor; and stability of operations under varying load conditions.

New name of Pennsylvania Salt Manufacturing Co., Philadelphia, will be Pennsalt Chemicals Corp. □

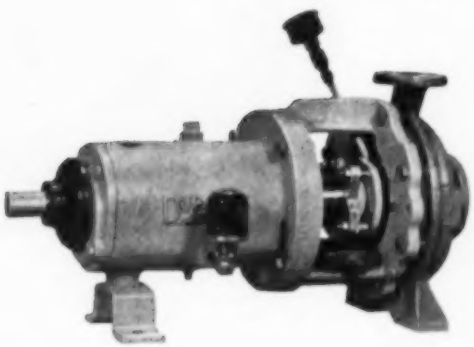
Major $2.5 million adhesives manufacturing plant will be built in Akron, Ohio, by B. F. Goodrich Co. The new plant is expected to be on-stream in 1958. □



NO DURCOPUMP FAILURE

in 24-hour alum service at

The CROSSETT Company, Crossett, Ark.



Series H Durcopump. A heavy duty process pump to handle high heads at most capacity ranges at normal or elevated temperatures.

Because Durcopumps have given excellent service under acid conditions in their Kraft Paper Mill, The Crossett Company specified additional Durcopumps for pumping alum solutions in the stock preparation area of their new Bleached Food Board Mill. The pumps illustrated are part of a continuous system preparing dilute rosin, starch, and alum for addition to the stocks. One pump operates twenty-four hours a day, seven days a week. The other pump is a standby, as down time would mean a plant shut-down. To date there has been no down time due to pump failure, and there has been no maintenance beyond routine servicing.

The Crossett Company's new mill produces 150 tons daily of bleached food container and packaging board. The new mill utilizes both pine pulp and pulp from some grades of hardwood timber previously in only limited use. It is the first mill of its kind.

Why not let Durco help solve your corrosion problems, too? For pumps, valves, filters, and other engineered equipment to handle corrosive solutions, call or write.

THE DURIRON COMPANY, INC.

DAYTON, OHIO *TELEPHONE KEnmore 2121*

DURCO
CORROSION RESISTING ALLOYS & EQUIPMENT

Branch Offices: Atlanta, Baltimore, Boston, Buffalo, Chicago, Cleveland, Dayton, Detroit, Houston, Knoxville, Los Angeles, New York, Philadelphia and Pittsburgh

PROTECTING JET ENGINE PARTS with Sicon Silicone Coating



Allison J-35 A-35 assembly of Solar-built parts. SICON is used as a protective coating on combustion chambers, aft-frames, other jet engine parts, and afterburners.



Operator masks end of combustion chamber with simple cardboard shields as he applies SICON finish to resist temperatures up to 800°F.



This J-35 afterburner shroud assembly has been masked at critical hole patterns and threaded attachments before being sprayed with SICON silicone coating.

HEAT RESISTANCE UP TO 800°F. *plus* EASY APPLICATION

An example of how SICON solves Finish Problems for Design Engineers.

Jet engine parts made by Solar Aircraft are fabricated from special aluminized steel to meet conditions of extremely high temperatures. Certain welding operations destroy the aluminized surface, and at such critical points SICON was first adopted as a touch-up finish to renew vital protection needed. SICON proved stable under searing heat tests due to its strong film adhesion and excellent heat resistance characteristics, also so easy and fast to apply that many parts are now given an all-over SICON coating.

Rigorous heat tests have proved SICON best for many other products such as automobile manifolds, exhaust pipes, furnaces, and heaters. SICON is easy to apply, by brush, spray, or dip, to any chemically clean surface; and in many cases can be either air-dried or baked.

Decorative colors for lower temperature needs—whites, beiges, tans, and other shades, all with excellent retention of color and gloss in the 550°F. range, are now available.

Write us about your problem. If a SICON formulation is indicated we will provide a sample based on color and temperature requirements. Dept. G-28.

MIDLAND Industrial Finishes Co.
EAST WATER ST., WAUKEGAN, ILLINOIS
ENAMELS • SYNTHETICS • LACQUERS • VARNISHES

Sicon

INDUSTRIAL NEWS

Vinyl stearate will soon be coming into the U. S. market from the new Calvert City, Ky., plant of Air Reduction Chemical Co. at a rate of two million pounds per year. Startup is expected by the end of the year.

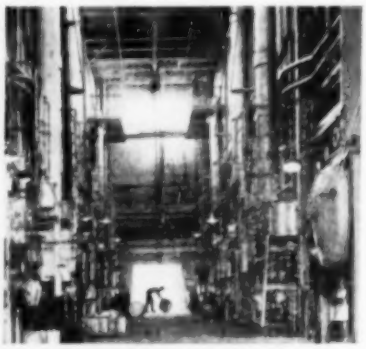
Promising applications are many. Vinyl stearate-vinyl acetate copolymers make excellent vehicles for exterior emulsion paints. High water resistance makes this combination a natural choice for adhesives, paper coatings, and textile finishes.

Copolymerization with vinyl chloride gives a flexible and stable coating material for food packaging, and fabric and electrical coatings. Copolymers containing a lower percentage of vinyl stearate are rigid materials lending themselves to use in plastic tubes, pipes, and other extruded forms. □

A new building at Cortland, N. Y., will serve as central office and plant for both Trinity Equipment Corp. and its subsidiary, Industrol Corp. □

The Girdler Co. has been authorized to proceed with the design and engineering of a gas purifying plant for Dow Chemical to be located at Bay City, Michigan. Erection will be by the Austin Co. □

Union Carbide and the Vanadium Corp. of America have been found not guilty of conspiring to monopolize and fix prices in the vanadium industry. The decision was handed down recently by a jury in the U. S. District Court in Denver, Colo. □



Fifteen new distillation units shown here are part of a $1.5 million expansion program at the Union Beach, N. J., plant of van Ameringen-Haebler. Designed for the production of aromatic chemicals, the new units include three-column continuous operation equipment and various other stills for large volume batch production. In addition to this new distillation equipment, the company has recently installed a number of specially designed reaction kettles and other equipment that will permit broader utilization of hydrogenation processes.

YOU JUST CAN'T

BUILD A FILTER

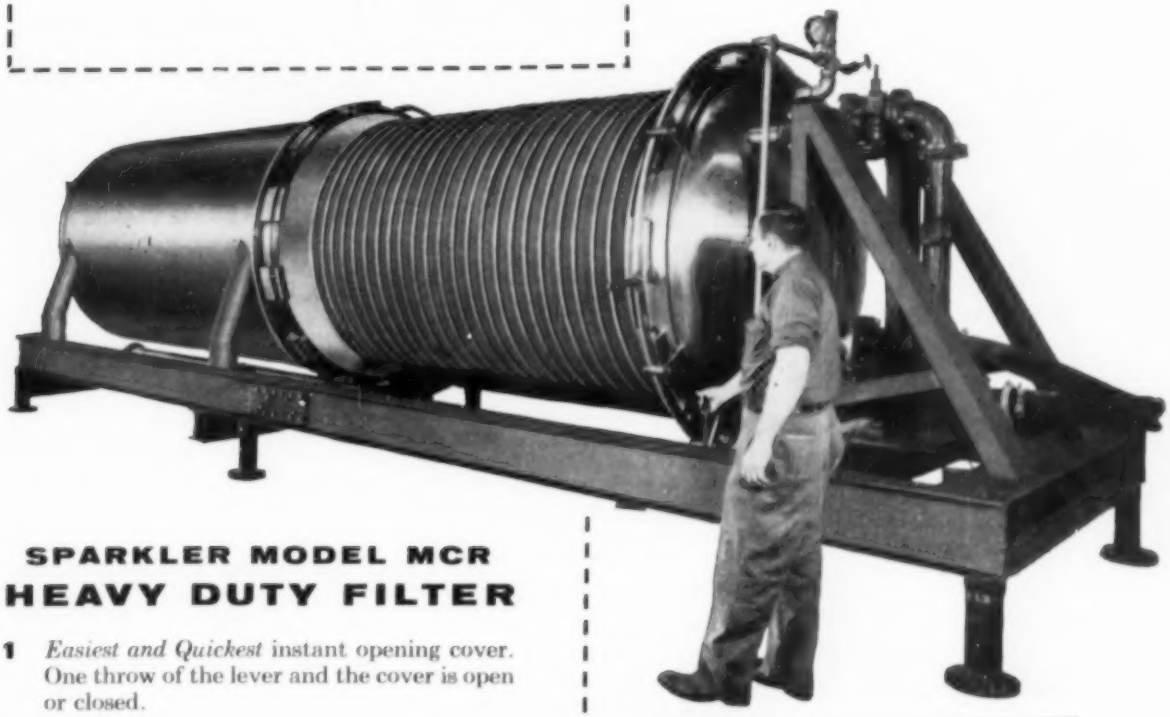
THIS GOOD

FOR LESS MONEY

Built to handle products with a high percentage of solids, with long operating cycles.

Engineered to lower filtration costs.
Fast cleaning with a minimum of down time.

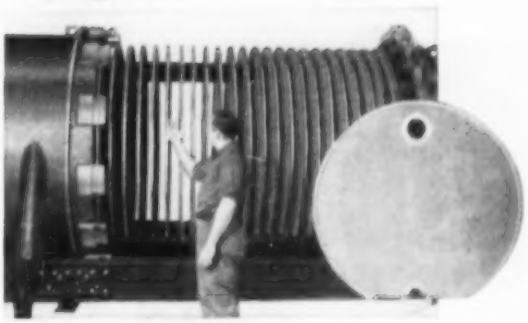
Anyone interested in reliable uniform quality, highest daily volume production, and economical operation, will not be satisfied with anything less than a Sparkler MCR.



SPARKLER MODEL MCR
HEAVY DUTY FILTER

1. *Easiest and Quickest* instant opening cover. One throw of the lever and the cover is open or closed.
2. Retractable tank, hydraulic power operated with finger tip control.
3. No breaking of pipe connections with fixed head. No spillage.
4. Plates spread far apart to allow full size cake without clogging. Large top plate outlet and bottom drainage outlet reduces flow resistance.

Write for complete facts in bulletin



SPARKLER FILTERS

SPARKLER MANUFACTURING COMPANY
Mundelein, Illinois

Sparkler International Ltd. plants, in Canada, Holland, Italy and Australia

Exclusive filtration engineers for over 30 years

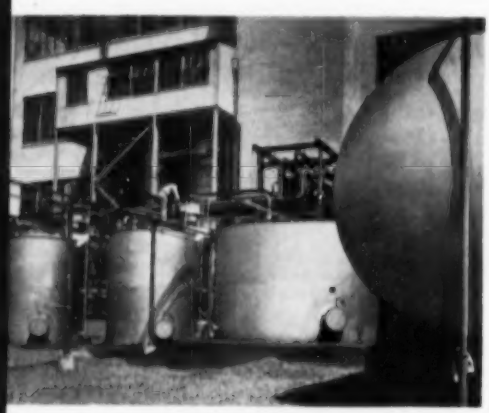
FIRST COMMERCIAL "ZIEGLER POLYOLEFIN" PLANT IN U. S. GOES ON-STREAM

Hercules Powder Co.'s new low-pressure polyethylene plant goes into production at Parlin, N. J. with process-inventor Ziegler present. New markets are expected for the product, Hercules already studying commercial possibilities of polypropylene.

Designed for a capacity of 30 million pounds of the new low-pressure Ziegler catalyst polyethylene and costing over $10 million, Hercules new Parlin plant is the first commercial-scale installation in the U. S. to use the Ziegler process. Raw material ethylene comes from Esso Standard's Linden, N. J. refinery. Resulting polyethylene comes out as a small particle-size solid, is purified, dried.

Hercules engineers have designed all polymerizing and compounding equipment specifically for the new plant, which is highly instrumented.

The frequent initial marketing and operational "shakedown" problems involved in new plants producing new products by new processes are not expected to cause any trouble, according to Hercules. The company cites as reason its having operated a semi-works plant at Parlin for a long time, the new commercial plant being an exact replica, operating techniques and conditions representing closest possible extrapolation. In the market area, through an arrangement with Farbwerke Hoechst AG of Frankfurt/Main, Germany (the first company in the world to produce polyethylene commercially by the Ziegler process), Hercules has been marketing the German-produced product in the U. S. for two years so that customers could test the material.



In-process tanks in front of process building of Hercules' new low-pressure plant.

The Product and The Process

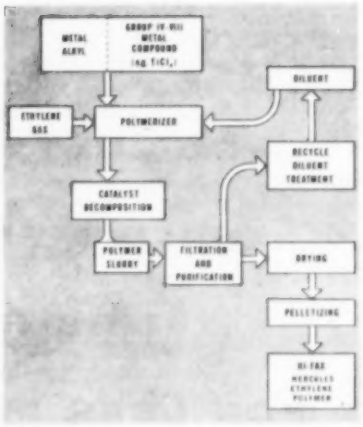
Understandably, Hercules is doing a lot of talking about its product, little about its process. The product is a linear polyethylene polymerized in the temperature range 70-200° F., at or near atmospheric pressure. It shows a greater density than standard high-pressure polyethylene (0.95 *vs.* 0.92), higher heat resistance (melting point 30-40° F. higher), two or three times the tensile strength, flexural strength doubled, greater surface hardness, improved chemical resistance and lower vapor permeability—all according to Hercules' own tests. It can be sterilized in boiling water and its impact strength remains relatively unchanged at temperatures as low as −40° F. (Spencer Chemical's high pressure, non-linear polyethylene has a density of 0.935, will also stand boiling water.)

As far as the process goes, the catalyst is said to be aluminum triethyl activated with titanium tetrachloride. The catalyst system is added to the diluent in a polymerizer and ethylene gas is piped into the mixture resulting in the linear polyethylene. The polyethylene is then slurried in the diluent after first being treated to decompose the catalyst, is filtered and purified. After drying, the polymer is pelletized to produce commercial polyethylene powder.

Versatility Plus

Essence of the Ziegler process is its versatility. There are many thousand catalyst combinations that can be described as Ziegler catalysts and the resulting polymers vary markedly in properties. As Ziegler said, "We found a nearly unlimited field of new organometallic mixed catalysts." By the proper choice of catalyst and reaction conditions, ethylene polymers can be produced ranging in density from as high as 0.96 to polymers that are soft and tough and comparable to standard high-pressure polyethylene now produced. It all depends on the market. Hercules can supply other types, with other properties, should the market develop.

At Hercules they are already in lab or pilot plant with other polyolefins, copolymers, and alloys, all aimed at outlets not attainable by polyethylene alone.



Schematic flow sheet of Hercules' plant.

To watch: Polypropylene. Hercules is currently in active evaluation of polypropylene on a lab scale, hopes that market development work during the next year will justify commercial-sized facilities.

The Market

There has been much talk in chemical engineering circles about possible over-optimistic building in the blossoming low-pressure field. In answer to this Konrad Weil of Farbwerke Hoechst was emphatic: "From time to time someone tries to scare us . . . with gloomy prophecies such as over capacity in plastics, particularly that these plastics are far from meeting all and every requirement as yet, but we are not afraid. We are firmly convinced that despite the large scale application of plastics of all kinds we are only at the beginning."

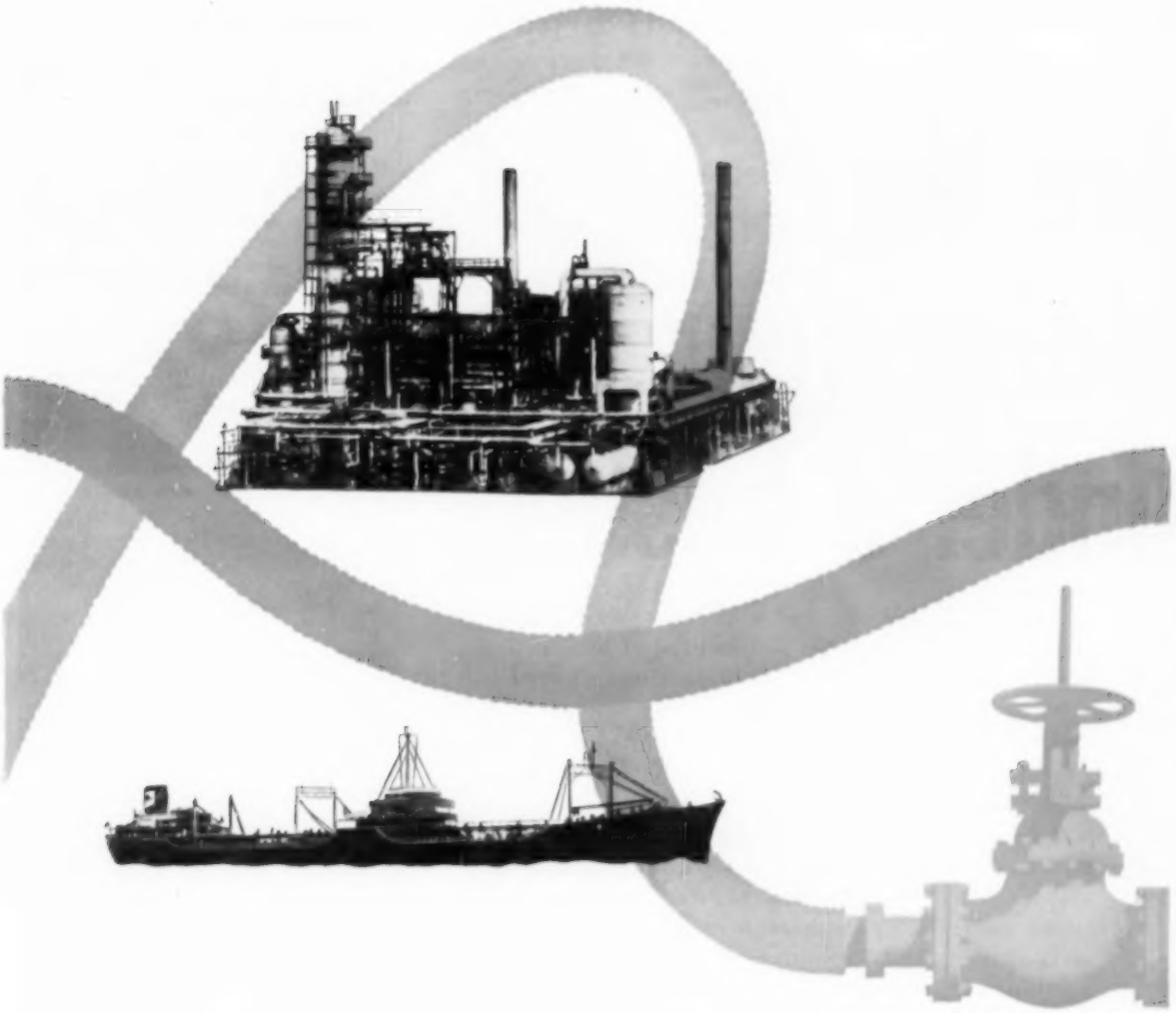
For Hercules the question of market is two-fold: is there a big enough market for low-pressure polyethylene; and how will the competition shape up between its Ziegler product and the products of the Phillips and Standard of Indiana processes? The second question can only wait for time to tell.

But the first question has plagued market-wise engineers for some time. The main answer has always stressed, and Hercules repeats, that low-pressure polyethylene is not expected to compete too much with already established plastics, but rather to create new markets of its own. Yet it is clear

(Continued on page 60)

TURN FOR MORE NEWS ON

INDUSTRY .....page 60 et seq.
NUCLEAR 88
OVERSEAS 96
INSTITUTIONAL 98
RESEARCH 101



Sun Ship has furnished equipment for many major oil companies in America

Of essential importance to American welfare is the free, expanding progress of the Oil Industry. Tankers for many of the oil companies have been built in the Sun Ship Yard. Also, refining equipment repairs and replacements have been furnished for the major oil companies.

In addition, Sun builds special machinery and fabricated steel products for a variety of other industries whose problems have been a welcome challenge—readily accepted—easily solved. Call or write our Sales Engineering Department about your plans—or problems. Immediate, courteous attention is assured.

Sun

SHIPBUILDING & DRY DOCK COMPANY

ON THE DELAWARE (SINCE 1916) CHESTER, PA.

Are they hiding your light under a bushel?

. . . under a bushel of detail work? Are you lost in an acre of engineers? Are you so tired of hoeing the same old row, you're ready to slaughter a sacred cow . . . or two? This is no way to enjoy engineering! You can avoid this kind of situation by choosing a company that places a premium on creative ability . . . individual initiative.

Take the Tonawanda Engineering Laboratories of LINDE for example. LINDE engineers have draftsmen to do their drawings . . . technicians to do their routine bench work. Each man shares his office with only one or two others. This atmosphere, free of tiresome, routine chores, encourages the solution of tough engineering problems . . . makes it easier to demonstrate qualities for advancement.

This is pretty heady stuff . . . and not every engineer can qualify. The work is in the production and distribution of atmospheric gases as gases and as low temperature liquids. The background required is in thermodynamics, heat and mass transfer, and stress analysis as applied to pilot plants, equipment development, process engineering and plant design.

There are a limited number of important opportunities available now. If you consider yourself one of the better engineers, write to Mr. R. P. Kalle, Dept. CP-7, Linde Company, Division of Union Carbide Corporation, P. O. Box 44, Tonawanda, N. Y.

Linde

UNION CARBIDE

50 YEARS OF LEADERSHIP

POLYOLEFIN

(*Continued from page* 58)

that there will be a certain amount of competition with existing plastics and again only time can tell how low-pressure will fare. Hercules, at least, is confident, already claims many industrial and consumer applications.

The Dokter Himself

Highlight of Hercules' opening ceremonies was, of course, the presence of Dr. Ziegler himself. Designating the day one of the most significant of his life, Ziegler went on to explain that the often-stated "accidental" discovery of his process is somewhat exaggerated. True, the exact moment of discovery came when he was working in another direction, but the "moment" was the result of twenty-five years work in the field of organometallics.

With a strong bow to the chemical engineers and the businessmen of the chemical industry, Dr. Ziegler emphasized, "It is a long way from such a fundamental discovery to a well-planned large-scale plant. The inventor has very little chance for coming to an economic success without the confidence, the courage, and the aid of his licensees."

Two major expansions of plants producing concentrated dispersions of carbon black have just been completed by Acheson Dispersed Pigments Co., a unit of Acheson Industries. The plants are in Texas and Ohio, new production is intended largely for the growing polyethylene market. □

Hercules Powder Co. has changed the name of its Missouri Ammonia Works at Louisiana, Mo., to Missouri Chemical Works. Reason is that Missouri Chemical now produces pentaerythritol and formaldehyde, is erecting a new methanol plant at its site. □

Cerro de Pasco Corp. has established a new Products Development Division to investigate and develop new products for addition to the company's line of semi-fabricated metal goods. □

New facilities will bring a 100% increase in production capacity of cuprous chloride at the Berkeley Heights, N. J., plant of Berkeley Chemical Corp. The new plant has been engineered so that production can be doubled again if required. □

Crane Valves Handle Corrosive Fluids Without Costly Leakage



Valve life more than doubled in this corrosive brine service

After more than 10 years' service on strong brine, these valves are still operating with high efficiency.

They are Crane No. 461 iron body gates, installed on a brine and condensate line at the world's largest sea water salt plant—located in Newark, Calif., and owned by Leslie Salt Co.

Before changing to the Crane valves, the plant was having difficulties with lubricated plug cocks. The plugs pitted; the cocks leaked continually, and had to be repiaced within 5 years. Installing Crane iron gate valves put a stop to the problem, eliminating leakage and replacement costs.

For more information on Crane iron body valves for many corrosive services, see your local Crane Representative, or write to Crane Co., address below.



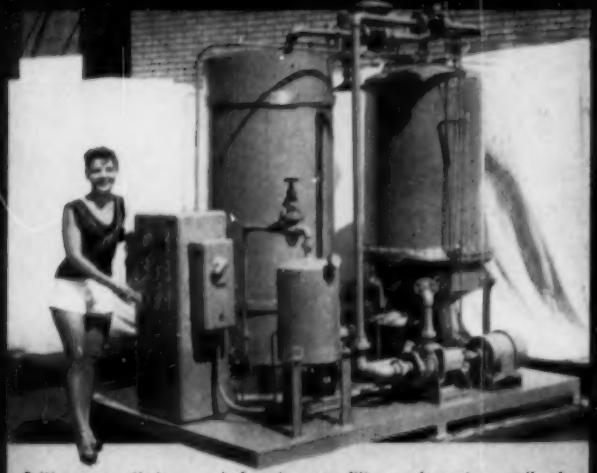
GET YOUR COPY of "Valve Performance Facts"—32 illustrated case histories covering valve installations throughout industry.

CRANE VALVES & FITTINGS

PIPE • PLUMBING • KITCHENS • HEATING • AIR CONDITIONING

Since 1855—Crane Co., General Offices: Chicago 5, Ill., Branches and Wholesalers Serving All Areas

CROLL-REYNOLDS
presents
new ClaRite FILTERS
...in an OUTSTANDING
5-STAR performance



Critics agree that never before has any filter performed so well — by eliminating particles down to 1/10 of a micron with unequaled flow rates, ClaRite filters combine the highest throughput with brilliant clarity.

AND CROLL-REYNOLDS' VERSATILE ClaRite FILTERS RATE 5-STARS BECAUSE THEY

SAVE MONEY — no need for bags, pads, cloths, cartridges, etc. . . . longer runs are achieved . . . overall cost of production reduced unbelievably.

SAVE LABOR — high velocity backwash eliminates manual disassembly and cleaning once and for all! . . . a few moments of labor time per filter cycle certainly will be a saving for you when compared with your present labor cost.

SAVE TIME — unique wedge opening tubular filter membranes give 3-5 times greater flow with less surface area than other types of filters . . . downtime for cleaning is reduced to a few minutes . . . absolute minimum loss of filtration time assured.

SAVE TROUBLE — permanent membranes and top quality accessories prevent breakdowns, costly delays and loss of expensive product through leakage, clogging or break through of filter media . . . an unequaled simplicity of maintenance achieved in ClaRite design.

IMPROVE YOUR PROCESS and PRODUCT increase flow rate and process efficiency . . . impressively improve filtration clarity, whether your process is small or large, batch or continuous, mild or corrosive.

Standard ClaRite filters, offered according to specific requirements in three types of filter membranes, are available with from 5 to 185 sq. ft. of filtration area, constructed of carbon steel, stainless steel, or lined carbon steel. Special designs available for larger or smaller units or for units constructed of other materials. For additional information, write today.

EXPERIENCE IN A VARIETY OF INDUSTRIES —

ACIDS
ALCOHOLS
BEVERAGES
CAUSTICS
COSMETICS
DRY CLEANING SOLVENTS
EDIBLE OILS
ELECTROPLATING SOLUTIONS
EXTRACTS
FOOD PRODUCTS
GENERAL CHEMICALS
INDUSTRIAL SOLVENTS
LACQUERS, STAINS
LIQUID DETERGENTS
LIQUID FUELS
METAL RECLAIMING
PHARMACEUTICALS
PHOTOGRAPHIC SOLUTIONS
PIGMENTS
SALT BRINE SOLUTIONS
STEAM CONDENSATE
SYNTHETIC FIBRES
VITAMINS
WATER
WINES and DISTILLED PRODUCTS

Croll-Reynolds
ENGINEERING CO. INC

INDUSTRIAL NEWS

The new 80,000 bbl. a calendar day vacuum pipe still being built by Fluor for the Port Arthur refinery of the Texas Co. will be one of the largest crude units in operation. When it goes on stream, Texaco will withdraw from operation existing units having a capacity of 60,000 bbl. a calendar day, resulting in a net increase of 20,000 bbls. a calendar day. The new units will include a desalting unit, crude and vacuum fractionation unit, light ends fractionation unit, H_2S removal unit, and a decarbonization unit for the production of high-grade catalytic cracking charging stock from vacuum residuum. The project is scheduled for completion early in 1958. □

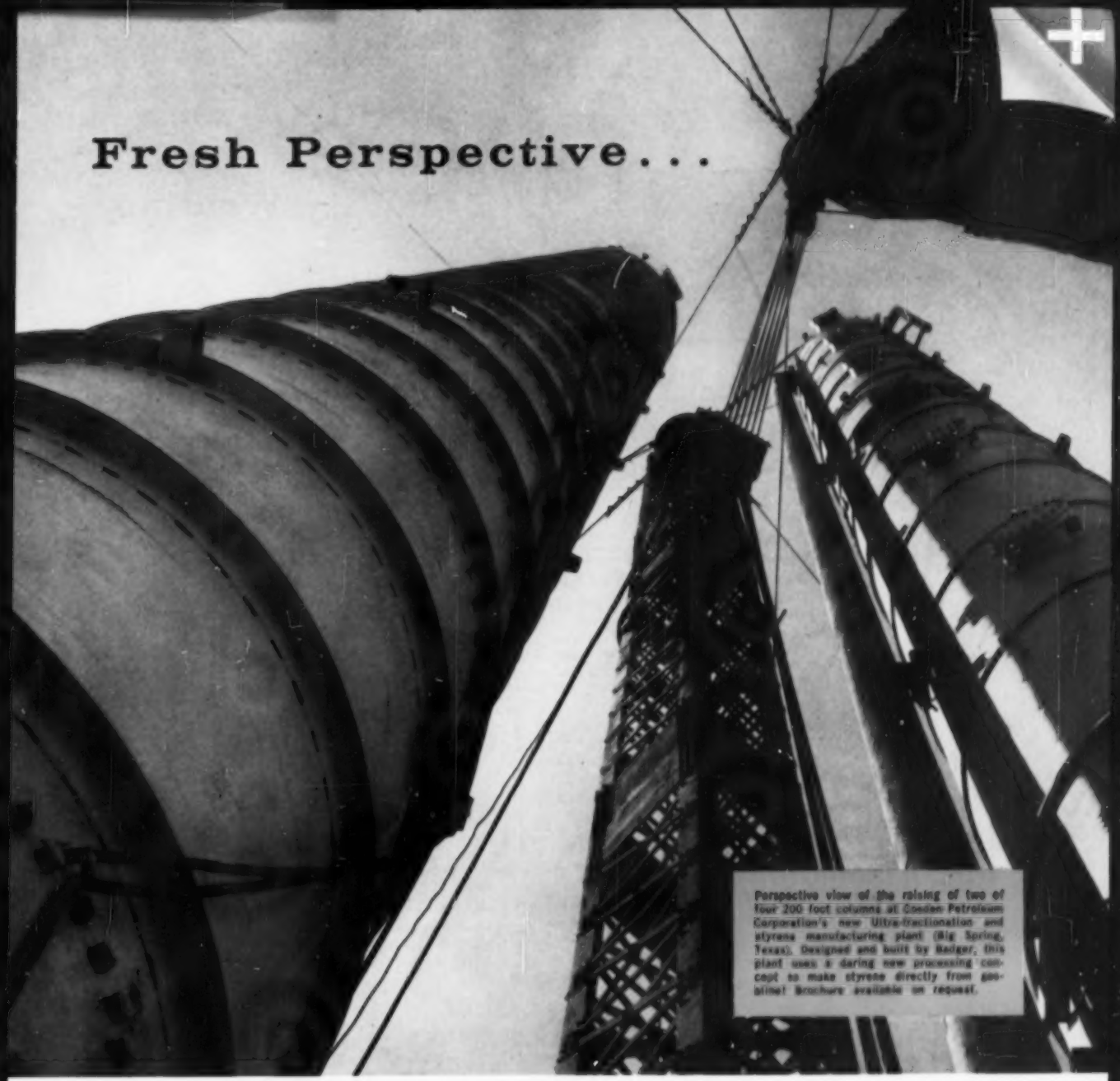
Twelve electric furnaces will produce ferroalloys at the new Roane Electric Furnace ferroalloys plant of Tennessee Products & Chemical Corp. at Rockwood, Tenn. The new plant is the latest of 13 plants built by Tennessee Products, a subsidiary of Merritt-Chapman & Scott Corp. □

A new plant for the production of ethylenediamine has started operations at Dow Chemical's Texas Division plant at Freeport, Tex. It will substantially expand the company's capacity for the versatile chemical. The ethylenediamine produced will now be able to have a concentration of 92% or greater, which is a significant increase over previously available concentrations. In addition, the plant will produce diethylenetriamine and triethylenetetramine. □

New plant for the production of meta "Delphene," effective new insect repellant, is now in production for Hercules Powder Co. at the company's site in Brunswick, Ga. □

As part of a $3.5 million improvement program at its Trona, Calif., plant, American Potash and Chemical Corp. is doubling production capacity of granular potash. Installation of the new potash granulating units is being done in two parts with the final half scheduled for completion by the end of this year. □

A new company to operate in the detergent and chemical specialties field has been formed in Blue Island, Ill. Named Surfacto Co., Inc., it has been formed by W. F. Tomlinson, former director of research and development for Stephan Chemical Co. of Chicago. □



Perspective view of the raising of two of four 200 foot columns at Cosden Petroleum Corporation's new Ultra-fractionation and styrene manufacturing plant (Big Spring, Texas). Designed and built by Badger, this plant uses a daring new processing concept to make styrene directly from gasoline! Brochure available on request.

+ The ability to put engineering problems in a *fresh perspective* — to subject them to a point of view that leads to new solutions — is at the root of Badger accomplishments like these:

. . . a commercially practical method of separating ethylbenzene from gasoline by Ultra-fractionation.

. . . a continuous process for producing sodium-hydrogen compounds.

. . . the successful application of a new process for deriving high quality light oils from coal — without acid treating.

An intangible that has been called "The Precious Plus behind a Badger blueprint," this refreshing ability to apply *new* thinking to difficult engineering problems has produced two important results:

1. Top petroleum and chemical processors are securing better processes, more economical plants.

2. Badger has become one of the world's fastest growing contract engineering firms.

Whether your project is commonplace or complex, calling in Badger is the first step toward securing the precious advantages that can come only from taking a *fresh perspective.*

Badger's Key Man Operating Policy: "The Badger man who submits your proposal is always a Badger principal — always the Key Man responsible for the execution of your job."

BADGER

MANUFACTURING COMPANY

230 Bent St., Cambridge, Mass.
New York, N.Y. • Houston, Texas
IN EUROPE: Badger-Comprimo N.V., The Hague
Badger-Comprimo S.A., Antwerp

ENGINEERS · CONTRACTORS · DESIGNERS · MANUFACTURERS

Skilled Then... in Quality Riveting As Today... in Quality Welding



Riveted Semi-elliptical Fire Still—1919

-GRAVER-



— 50,000 —
—100,000—
—150,000—

GALLON TANKS (like cut) IN STOCK
For PROMPT SHIPMENT & ERECTION
WRITE for PRICES & SPECIFICATIONS

In **1857** with a small shop and all hand tools, we demonstrated our ability to make **good** tanks. In **1913** with a large plant most fully equipped with modern power tools, we are able to demonstrate our ability to make **better** tanks. The passing years have taught us many things, but best of all they have demonstrated to the trade in general the soundness of our early theories on tank construction.

STEEL TANKS AND PLATE WORK

Material in stock for small tanks of 500 to 20,000 gallons capacity

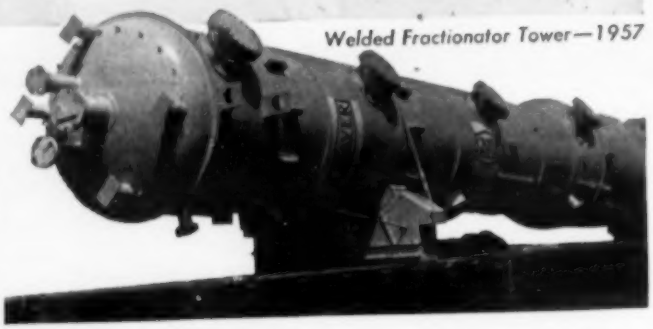
WM. GRAVER TANK WORKS
EAST CHICAGO, IND. (148th and Todd Ave.)

DENVER, COLO., 1718 California St. | SALT LAKE CITY, 109 West Second St. | LOS ANGELES, CAL., 312 Security Bldg.



Some of the many types of riveted fabrication by Graver, as advertised in National Petroleum News, July, 1913

Welded Fractionator Tower—1957



Joining plate with rivets for processing equipment, pressure vessels and storage tanks would be quite unsatisfactory today. Yet, before welding became an accepted fabricating technique, to which Graver contributed measurably in perfecting, Graver's boring and riveting methods were recognized as the most advanced in the country. Today, the most advanced welding, X-ray testing, stress-relieving and assembly methods are employed. This is what you can always expect from Graver—a pioneer in skilled steel and alloy fabrication for 100 years!

1857-1957 GRAVER *Our 100th Year*

Building for the Future on a Century of Craftsmanship in Steels and Alloys

GRAVER TANK & MFG. CO., INC.

EAST CHICAGO, INDIANA • NEW YORK • PHILADELPHIA • EDGE MOOR, DELAWARE
PITTSBURGH • DETROIT • CHICAGO • TULSA • SAND SPRINGS, OKLAHOMA
HOUSTON • NEW ORLEANS • LOS ANGELES • SAN FRANCISCO • FONTANA, CALIFORNIA

CEP Data Service



DEVELOPMENTS OF THE MONTH

389 New Steam Trap Development. The Velan Monovalve Float Thermostatic Steam Trap makes it possible to discharge condensate at steam temperature. Four-purpose valve replaces two seats and valves in standard traps and three seats and valves in installations with check valves. It incorporates all the features of the bimetal design that guarantee maximum condensate flow at steam temperature.

For cool condensate, the valve operates as in standard bimetallic steam traps. However, if steam-hot condensate enters the trap body, and the bimetallic operated valve is closed, the float is lifted by the accumulating water and pushes the valve to full open position, allowing high-capacity discharge of steam-hot condensate. The valve is free-floating and can move back in the same way as in standard steam traps, acting as a check valve to prevent back flow of condensate. Technical bulletin available from the Velan Valve Corp. Circle number 389 on Data Post Card.

ENGINEERING DATA—EQUIPMENT

301 Chemical Motors. Specially-designed for dangerous or damaging atmospheres. Totally-enclosed and explosion-proof. Available from 3 to 150 hp. Bulletin from U. S. Electrical Motors, Inc.

302 Pulse Code Telemetering System. Precise reports on liquid levels available in a few seconds to operators, recorders, or controllers regardless of distance. Technical bulletin from Vapor Recovery Systems Co.

303 Sealless Pump. No stuffing boxes or shaft seals of any kind. Pumping mechanism and permanently-lubricated ball bearings completely out of fluid area. Full technical information from Vanton Pump & Equipment Corp.

304 Honeycomb Filter Tubes. For micronic clarification of liquid chemicals. Made in a variety of natural and synthetic fibers—cotton, nylon, orlon, dacron, dynel, acetate, and glass fibers. Bulletin from Commercial Filters Corp.

305 Condensate Return Pumps. Bulletin from C. H. Wheeler Manufacturing Co. gives technical details of line of vertical centrifugal condensate return pumps. Construction features, selection table, and typical specifications.

306 Pneumatic Instruments. Pilot controllers, transmitters, receivers, and recording controllers. Technical bulletin from United States Gauge Division of American Machine and Metals, Inc.

307 Pre-Setting Ring for Mechanical Seals. Seal is assembled as a cartridge unit ready for installation. No field fitting is required. Complete information from Byron Jackson Pumps, Inc.

308 Brass Tube Fittings Catalog. Lists all sizes and types of brass fittings manufactured by the Weatherhead Co. 48 pages.

309 Flexible Metal Hose and Bellows. Engineering specifications and sizes, pressure ratings, materials, and fitting attachments. Detailed drawings and charts. Bulletin from Flexonics Corp.

310 Automatic Valveless Filter. Literature from the Permutit Co. describes new valveless filter which can be used wherever gravity flow is feasible. Instrumentation and auxiliaries eliminated, manpower and maintenance reduced to minimum.

311 Sludge Pumps. Brochure from Komline-Sanderson Engineering Corp. describes line of diaphragm and plunger type dual valve sludge pumps for handling sludges and chemical slurries.

312 Standard Thermocouple Assemblies. Bulletin from Claud S. Gordon Co. gives catalog numbers, sizes, prices, and ordering information on wide variety of "Serv-Rite" thermocouple assemblies.

(Continued on page 70)

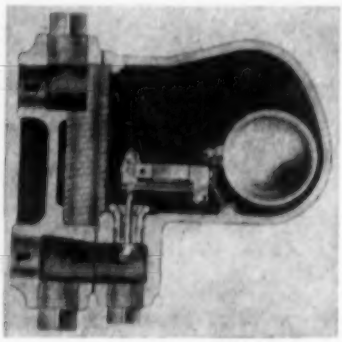
DEVELOPMENTS OF THE MONTH (Cont.)

390 Industrial Television Systems. Allen B. Du Mont Laboratories announces a complete range of industrial television equipment. Two lines are offered based on cameras in two price ranges. The self-contained TC-100 model requires no external power supply or control unit. Furnished with optional three lens turret, the camera is said to produce bright, clear pictures with light levels as low as ten or fifteen footcandles. Basic camera measures 5 in. wide, 7½ in. high, 12 in. long, and weighs 12 pounds. Completely installed closed-circuit television systems incorporating the TC-100 are available at about $2,000.

The deluxe TC-200 model is a miniature three-pound camera, 3 in. wide, 3½ in. high, 10 in. long. It produces a high resolution, 2:1 interlace television signal, and can be operated up to 2,000 feet from its control unit. Cost of a complete system utilizing this more expensive model is approximately $3,500. Quick reference catalog covering this equipment is available from the manufacturer. Circle number 390 on Data Post Card.



CEP Data Service



DEVELOPMENTS OF THE MONTH

389 New Steam Trap Development. The Velan Monovalve Float Thermostatic Steam Trap makes it possible to discharge condensate at steam temperature. Four-purpose valve replaces two seats and valves in standard traps and three seats and valves in installations with check valves. It incorporates all the features of the bimetal design that guarantee maximum condensate flow at steam temperature.

For cool condensate, the valve operates as in standard bimetallic steam traps. However, if steam-hot condensate enters the trap body, and the bimetallic operated valve is closed, the float is lifted by the accumulating water and pushes the valve to full open position, allowing high-capacity discharge of steam-hot condensate. The valve is free-floating and can move back in the same way as in standard steam traps, acting as a check valve to prevent back flow of condensate. Technical bulletin available from the Velan Valve Corp. Circle number 389 on Data Post Card.

ENGINEERING DATA—EQUIPMENT

301 Chemical Motors. Specially-designed for dangerous or damaging atmospheres. Totally-enclosed and explosion-proof. Available from 3 to 150 hp. Bulletin from U. S. Electrical Motors, Inc.

302 Pulse Code Telemetering System. Precise reports on liquid levels available in a few seconds to operators, recorders, or controllers regardless of distance. Technical bulletin from Vapor Recovery Systems Co.

303 Sealless Pump. No stuffing boxes or shaft seals of any kind. Pumping mechanism and permanently-lubricated ball bearings completely out of fluid area. Full technical information from Vanton Pump & Equipment Corp.

304 Honeycomb Filter Tubes. For micronic clarification of liquid chemicals. Made in a variety of natural and synthetic fibers—cotton, nylon, orlon, dacron, dynel, acetate, and glass fibers. Bulletin from Commercial Filters Corp.

305 Condensate Return Pumps. Bulletin from C. H. Wheeler Manufacturing Co. gives technical details of line of vertical centrifugal condensate return pumps. Construction features, selection table, and typical specifications.

306 Pneumatic Instruments. Pilot controllers, transmitters, receivers, and recording controllers. Technical bulletin from United States Gauge Division of American Machine and Metals, Inc.

307 Pre-Setting Ring for Mechanical Seals. Seal is assembled as a cartridge unit ready for installation. No field fitting is required. Complete information from Byron Jackson Pumps, Inc.

308 Brass Tube Fittings Catalog. Lists all sizes and types of brass fittings manufactured by the Weatherhead Co. 48 pages.

309 Flexible Metal Hose and Bellows. Engineering specifications and sizes, pressure ratings, materials, and fitting attachments. Detailed drawings and charts. Bulletin from Flexonics Corp.

310 Automatic Valveless Filter. Literature from the Permutit Co. describes new valveless filter which can be used wherever gravity flow is feasible. Instrumentation and auxiliaries eliminated, manpower and maintenance reduced to minimum.

311 Sludge Pumps. Brochure from Komline-Sanderson Engineering Corp. describes line of diaphragm and plunger type dual valve sludge pumps for handling sludges and chemical slurries.

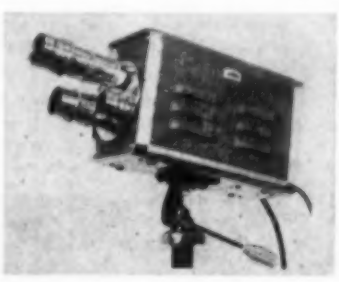
312 Standard Thermocouple Assemblies. Bulletin from Claud S. Gordon Co. gives catalog numbers, sizes, prices, and ordering information on wide variety of "Serv-Rite" thermocouple assemblies.

(Continued on page 70)

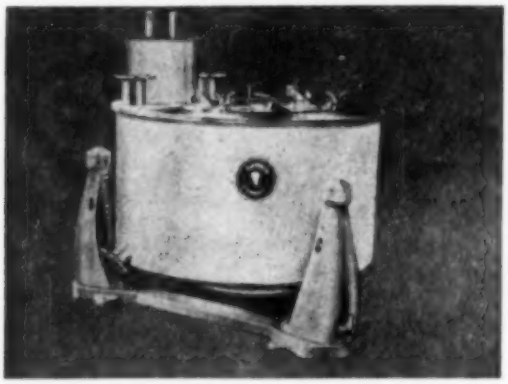
DEVELOPMENTS OF THE MONTH (Cont.)

390 Industrial Television Systems. Allen B. Du Mont Laboratories announces a complete range of industrial television equipment. Two lines are offered based on cameras in two price ranges. The self-contained TC-100 model requires no external power supply or control unit. Furnished with optional three lens turret, the camera is said to produce bright, clear pictures with light levels as low as ten or fifteen footcandles. Basic camera measures 5 in. wide, 7½ in. high, 12 in. long, and weighs 12 pounds. Completely installed closed-circuit television systems incorporating the TC-100 are available at about $2,000.

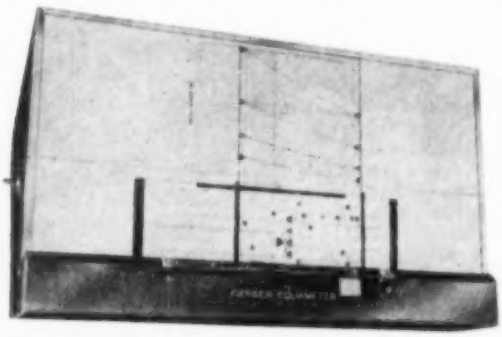
The deluxe TC-200 model is a miniature three-pound camera, 3 in. wide, 3½ in. high, 10 in. long. It produces a high resolution, 2:1 interlace television signal, and can be operated up to 2,000 feet from its control unit. Cost of a complete system utilizing this more expensive model is approximately $3,500. Quick reference catalog covering this equipment is available from the manufacturer. Circle number 390 on Data Post Card.



DEVELOPMENTS OF THE MONTH (Cont.)



391 Tripoint Suspension Centrifuge. The "Tornado" is a batch-type, bottom-discharge machine with fluid mechanic drive featuring variable speed, hydraulic regenerative braking. It can be furnished completely automatic with controls, relays, timer, etc. In a separate control panel, semi-automatic with a push-button station located on the machine, or adapted for manual operation with throttle control. Basket capacities range from 9 to 16 cu. ft. Approximate price is said to range from $15,000 to $25,000. A complete line of accessories is available for manual, semi-automatic, or fully-automatic operation. Machine can be supplied in carbon steel, stainless steel, or other metal of sufficient strength. Special rubber or plastic coatings or linings may be applied when required. Further information available from the manufacturer, the Fletcher Works. Circle number 391 on Data Post Card.



392 Manually-Operated Computer. Model GEQ-450 Gerber Equameter is a manually-operated computing device which performs harmonic analyses and curve fittings on plotted or recorded curves. The instrument is said to be capable of analyzing a curve in terms of Fourier Series, Power Series, or Orthogonal Polynomials (least square fits). It will also produce the derivative or integral equations of a given curve. These equations are obtained directly from readings taken from the Equameter and recorded on specially designed data sheets. The machine can be operated by persons with little or no mathematical training. The Equameter is made by the Gerber Scientific Instrument Co. For further information, circle number 392 on Data Post Card.

(Continued on page 67)

Numbers followed by letters are for checking your interest in the products, equipment, and services advertised in this issue, the number corresponding to the page on which the ad appears. Letters indicate position on the page: L, left; R, right; T, top; B, bottom. A indicates a full page; IFC, IBC, and OBC are cover advertisements. **Numbers in the 300-series** bring you new engineering data in the chemical engineering field.

Be sure to include your name, address, and position.

Please do not use this card after October, 1957

Advertisers' Products and Engineering Data

IFC 3R 4A 6A 7A 8L 9A 10-11A 13A 14A 15A
16L 17A 18A 21A 23A 24-25A 26B 27A 28A 29A 31A
32-33A 34L 35-36A 37A 39A 40TL 40BL 41A 42-43A 44L
45A 46L 47A 48A 50A 312A 51A 53A 54L 55A 56L
57A 59A 61A 62L 63A 64A 69A 71A 73A 75A 77A
79A 81A 82L 83R 84L 85A 86L 87A 88L 89A 90L
91A 92L 93A 95A 96L 97A 98L 99A 100A 101R 102L
103A 104A 108A 109R 110L 111A 112L 113A 114L 115A 116L
117A 119A 120L 121A 122L 123A 124L 125A 126TL 126BL
127A 128L 129A 130BL 131A 132TL 132BL 133R 134BL 135A
136TL 136BL 137L 137R 138BL 139A 142L 143TR 143BR 144BL
145TL 145BL 145TR 145BR 146L 146R 147A 148L 148R 154TL
154BL 155BL 155TR 155BR IBC OBC 301 302 303 304 305 306
307 308 309 310 311 312 313 314 315 316 317
318 319 320 321 322 323 324 325 326 327 328
329 330 331 332 333 334 335 336 337 338 339
340 341 342 343 344 345 346 347 348 349 350
351 352 353 354 355 356 357 358 359 360 361
362 363 364 365 366 367 368 369 370 371 372
373 374 375 376 377 378 379 380 381 382 383
384 385 386 387 388 389 390 391 392 393 394
395 396 397 398 399 400

Chemical Engineering Progress Data Service

Name .....
Position .....
Company .....
Address .....
City .....Zone.....State.....

☐ I want a subscription to C.E.P. Bill me $6.00 for a year.

July, 1957

Please do not use this card after October, 1957

Advertisers' Products and Engineering Data

IFC 3R 4A 6A 7A 8L 9A 10-11A 13A 14A 15A
16L 17A 18A 21A 23A 24-25A 26B 27A 28A 29A 31A
32-33A 34L 35-36A 37A 39A 40TL 40BL 41A 42-43A 44L
45A 46L 47A 48A 50A 312A 51A 53A 54L 55A 56L
57A 59A 61A 62L 63A 64A 69A 71A 73A 75A 77A
79A 81A 82L 83R 84L 85A 86L 87A 88L 89A 90L
91A 92L 93A 95A 96L 97A 98L 99A 100A 101R 102L
103A 104A 108A 109R 110L 111A 112L 113A 114L 115A 116L
117A 119A 120L 121A 122L 123A 124L 125A 126TL 126BL
127A 128L 129A 130BL 131A 132TL 132BL 133R 134BL 135A
136TL 136BL 137L 137R 138BL 139A 142L 143TR 143BR 144BL
145TL 145BL 145TR 145BR 146L 146R 147A 148L 148R 154TL
154BL 155BL 155TR 155BR IBC OBC 301 302 303 304 305 306
307 308 309 310 311 312 313 314 315 316 317
318 319 320 321 322 323 324 325 326 327 328
329 330 331 332 333 334 335 336 337 338 339
340 341 342 343 344 345 346 347 348 349 350
351 352 353 354 355 356 357 358 359 360 361
362 363 364 365 366 367 368 369 370 371 372
373 374 375 376 377 378 379 380 381 382 383
384 385 386 387 388 389 390 391 392 393 394
395 396 397 398 399 400

Chemical Engineering Progress Data Service

Name .....
Position .....
Company .....
Address .....
City .....Zone.....State.....

☐ I want a subscription to C.E.P. Bill me $6.00 for a year.

July, 1957

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 48890, Sec. 34.9, P. L. & R., New York, N. Y.

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

Postage Will Be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 48890, Sec. 34.9, P. L. & R., New York, N. Y.

CHEMICAL ENGINEERING PROGRESS
25 West 45th Street
New York 36,
New York

Postage Will Be Paid by Addressee

DEVELOPMENTS OF THE MONTH (Cont.)

393 Sodium Dispersions Data Book. U. S. Industrial Chemicals Co. offers forty-two page book describing every phase of preparation and application of sodium dispersions. An extended introduction discusses characteristics of sodium dispersions and the advantages of extended surface area. Also treated are typical applications, including purification and polymerization. Availability, formulations, and preparation are discussed at length. U.S.I. supplies sodium for dispersions —actual preparation is up to the user. However, U.S.I. offers free samples and technical services and is prepared to lend pilot units. Equipment and procedures required for preparation and use of sodium dispersions are described in detail. The book includes 8 tables and 33 figures. Circle number 393 on Data Post Card.

394 Giant Packed Column Redistributors. Distillation Engineering Co. announces packed column redistributors in sizes up to 6½ ft. diameter. They are said to have been performance-tested with Raschig rings, Berl saddles, Intalox saddles, and protruded packing, and to have shown, in most cases, an improvement in column plate efficiency of 100 per cent or over. The unit collects the liquid which tends to run down the column wall in an annular ring and distributes it evenly across the packing by means of vanes. A certain portion of the liquid is intercepted by the vanes themselves, thus equalizing the distribution still further. Redistributors are designed to have no effect on pressure drop, holdup, or throughput rate. A descriptive bulletin is available from the manufacturer. Circle number 394 on Data Post Card.

395 Hastelloy Data Book. 104-page booklet from Haynes Stellite Co., Division of Union Carbide Corp., gives up-to-date information on the four nickel-base alloys: Hastelloy B, C, D, and F. Brochure describes chemical compositions, physical, mechanical, and high-temperature properties of the alloys. Also included is a table of comparative resistances of the alloys to over 250 corrosives commonly handled in the chemical, petroleum, paper and pulp, pharmaceutical, and metalworking industries. Includes complete laboratory penetration data for common corrosives such as hydrochloric, sulfuric, nitric, phosphoric, acetic, and formic acids. Graphs show penetration rates at various acid concentrations and temperatures. Complete section of booklet describes techniques for forging, cold working, machining, grinding, and welding of the alloys. Circle number 395 on Data Post Card.

(Continued on page 70)

PRODUCTS ADVERTISED IN THIS ISSUE

IFC Propionaldehyde Data and Samples. Reaction products of propionaldehyde are important for alkyd and polyester resins, plasticizers, rubber accelerators. Complete information and samples from Union Carbide Chemicals Co.

3R Rotary Sifter Bulletin. Model "M" Bar-Nun Rotary Sifter can provide up to 40 sq. ft. of screen surface in floor space 3½ ft. square. B. F. Gump Co.

4A Entrainment Separators. Yorkmesh Demisters improve the performance of vacuum towers, distillation equipment, gas absorbers, scrubbers, evaporators, steam drums. Consulting services available from Otto H. York Co.

6A Polyethylene Tower Packing Data. "Tellerette," based on principle of interstitial holdup, said to ensure increased efficiency and capacity. Folder from Harshaw Chemical Co.

7A Pulverizing and Dust-Collecting Equipment. Sample testing and process recommendations on all types of grinding problems offered by Pulverizing Machinery Division, Metals Disintegrating Co.

8L Swivel Joint Catalog. Ball-bearing joint breaks like union for easy inspection and repacking. Catalog and price list from Continental-Emsco Co.

9A Matched Piping and Fittings. Seamless and welded tubular products, seamless welding fittings, and forged steel flanges in carbon, alloy, and stainless steel. Babcock & Wilcox Co.

10A-11A Diatomite Filter Aids. "Celite" is produced in wide range of standard grades plus many special grades for special applications. Technical data from Johns-Manville.

13A Special Purpose Steels. Crucible Steel Co. of America offers 44-page book "Making the Most of Stainless Steels in the Chemical Process Industries."

14A Centrifuges. Sharples Corp. will make arrangements for demonstration test on your product with their new Series P-3000 Super-D-Canter. High capacity dewatering and solids classification.

15A Industrial Jet Equipment. "Chill-Vactors," steam-jet evactors, fume scrubbers, special jet apparatus. Croll-Reynolds Co.

16L Heat Exchanger Design Data. Technical bulletin from Downingtown Iron Works, Inc. Also information on steel and alloy plate fabrication, containers, and pressure vessels.

17A Water Supply Services. Complete from water location to furnishing of specially-designed pumps. General services bulletin from Layne & Bowler, Inc., Memphis.

18A Air and Gas Compressors. Bulletin from Roots-Connersville Blower describes process applications of the "Spiraxial" type compressor.

21A Batch and Continuous Crystallizers. Laboratory facilities available for pilot testing of samples. Chicago Bridge & Iron Co.

23A Heat Transfer Med.um. For process heating problems at temperatures ranging from 350 to 750° F., Dowtherm, product of Dow Chemical Co., may be the economical answer. Literature.

24A-25A Centrifugal Pump Bulletin. 70,480 combinations from standard, stocked parts. Five types of liquid ends and five different drives. Worthington Corporation.

26B Fabricated Steel Structures. Tanks, digesters, pressure vessels, stacks, dredge pipe. Posey Iron Works, Inc.

27A Dryer Bulletin. Complete facts and technical information on line of dryers for all chemical processing needs. C. M. Kemp Manufacturing Co.

28A Methane Purification Process Plants. Low-temperature processing plants, designed and built by Air Products, Inc., produce methane containing less than 100 p.p.m. of other hydrocarbons.

29A Chromium Stainless Steels. G. O. Carlson, Inc., has large stock of Types 405, 410, and 430 chromium stainless plate available for quick delivery.

31A Data Sheets on Gas Drying. Give technical details on performance of "molecular sieve" adsorbents. Linde Co., Division of Union Carbide Corp.

32A-33A Asbestos Insulation Booklet. "Thermobestos" insulation, product of Johns-Manville, is available in pipe insulation form in sizes up to 30 in. O.D. Also in blocks in full range of thicknesses.

34L Portable High Efficiency Muller. Particularly adapted for pilot plants and small production requirements. Free mixing report on your product offered by Simpson Mix-Muller Division, National Engineering Co.

35A-36A Industrial Product Bulletins. U. S. Industrial Chemicals Co. offers bulletins on sodium dispersions, zirconium and hafnium application, and fabrication techniques, other new developments.

37A Non-Lubricated Plug Valves. Full range of valve materials and special plug facings available. Technical details from DeZurik Corp.

39A Bulk Material Conveying Systems. Feeders, conveyors, elevators, screens, hoists. Bulletins from Stephens-Adamson Manufacturing Co.

40TL Chlorinator Bulletin. W&T V-notch chlorinators, product of Wallace & Tiernan, Inc., are rugged, easy to operate, and moderately priced.

40BL Chlorine Detector. Will detect as little as 3 p.p.m. chlorine in a continuous air-stream sample. Bulletin from Wallace & Tiernan.

41A Fume Scrubber Bulletin. Describes equipment in wide range of sizes in cast iron, steel, Haveg, stoneware, rubber, or PVC-lined, or in other synthetic materials. Schutte and Koerting Co.

42A-43A Process Plant Design and Construction. Large butadiene plant for Firestone completed by Catalytic Construction Co. in less than nine months in the field.

44L Metallic Filter Cloth Catalog. All weaves, all metals, for all types of processing service. Newark Wire Cloth Co.

45A Mercury Arc Rectifiers. Factory-packaged units cut installation costs and time. Sealed tube rectifiers supplied in completely enclosed or open types. Allis-Chalmers.

46L Motor Pump Bulletin. Sizes ¼ to 75 hp., capacities to 2,800 gal./min., heads to 650 feet. Complete information from Ingersoll-Rand.

47A Magnetic Flow Meter. No erosion, no fouling. Flow measurements picked up electrically by flush-mounted electrodes. Accurate to one per cent of full scale. Technical details from Foxboro Co.

○ **CHECK** *your Data Service requests on the handy postcard on page 66 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

48A Non-Pressurized Heat Transfer Fluid. "Aroclor," non-pressurized, liquid-phase heat transfer fluid, does not support combustion up to its boiling range, 652 to 725° F. Non-corrosive. Technical information from Monsanto Chemical Co.

50A Cooling Tower Packing. "Poly-Grid" packing, product of the Fluor Products Co., is available in high-impact polystyrene or linear polyethylene.

312A Nozzle-Type Safety Relief Valves. Wide range of orifice sizes, and with inlet sizes from 1 to 8 in. Bulletin from Crosby Valve & Gage Co.

51A Processing Reagents. "Syloids," made by Davison Chemical Co., act as flatting agents for vinyls, lacquers and varnishes, as thickening agents for resins and inks, many other uses. Technical literature.

53A Process Valves. Bronze, iron, steel, and corrosion-resistant valves to fit every chemical processing need. Wm. Powell Co.

54L Heat Exchangers. For high operating pressures, severe temperature conditions, thermal shock. "Heliflow" exchangers are made by Graham Manufacturing Co.

(Continued on page 72)

PRODUCTS ADVERTISED IN THIS ISSUE

IFC Propionaldehyde Data and Samples. Reaction products of propionaldehyde are important for alkyd and polyester resins, plasticizers, rubber accelerators. Complete information and samples from Union Carbide Chemicals Co.

3R Rotary Sifter Bulletin. Model "M" Bar-Nun Rotary Sifter can provide up to 40 sq. ft. of screen surface in floor space 3½ ft. square. B. F. Gump Co.

4A Entrainment Separators. Yorkmesh Demisters improve the performance of vacuum towers, distillation equipment, gas absorbers, scrubbers, evaporators, steam drums. Consulting services available from Otto H. York Co.

6A Polyethylene Tower Packing Data. "Tellerette," based on principle of interstitial holdup, said to ensure increased efficiency and capacity. Folder from Harshaw Chemical Co.

7A Pulverizing and Dust-Collecting Equipment. Sample testing and process recommendations on all types of grinding problems offered by Pulverizing Machinery Division, Metals Disintegrating Co.

8L Swivel Joint Catalog. Ball-bearing joint breaks like union for easy inspection and repacking. Catalog and price list from Continental-Emsco Co.

9A Matched Piping and Fittings. Seamless and welded tubular products, seamless welding fittings, and forged steel flanges in carbon, alloy, and stainless steel. Babcock & Wilcox Co.

10A-11A Diatomite Filter Aids. "Celite" is produced in wide range of standard grades plus many special grades for special applications. Technical data from Johns-Manville.

13A Special Purpose Steels. Crucible Steel Co. of America offers 44-page book "Making the Most of Stainless Steels in the Chemical Process Industries."

14A Centrifuges. Sharples Corp. will make arrangements for demonstration test on your product with their new Series P-3000 Super-D-Canter. High capacity dewatering and solids classification.

15A Industrial Jet Equipment. "Chill-Vactors," steam-jet evactors, fume scrubbers, special jet apparatus. Croll-Reynolds Co.

16L Heat Exchanger Design Data. Technical bulletin from Downingtown Iron Works, Inc. Also information on steel and alloy plate fabrication, containers, and pressure vessels.

17A Water Supply Services. Complete from water location to furnishing of specially-designed pumps. General services bulletin from Layne & Bowler, Inc., Memphis.

18A Air and Gas Compressors. Bulletin from Roots-Connersville Blower describes process applications of the "Spiraxial" type compressor.

21A Batch and Continuous Crystallizers. Laboratory facilities available for pilot testing of samples. Chicago Bridge & Iron Co.

23A Heat Transfer Medium. For process heating problems at temperatures ranging from 350 to 750° F., Dowtherm, product of Dow Chemical Co., may be the economical answer. Literature.

24A-25A Centrifugal Pump Bulletin. 70,480 combinations from standard, stocked parts. Five types of liquid ends and five different drives. Worthington Corporation.

26B Fabricated Steel Structures. Tanks, digesters, pressure vessels, stacks, dredge pipe. Posey Iron Works, Inc.

27A Dryer Bulletin. Complete facts and technical information on line of dryers for all chemical processing needs. C. M. Kemp Manufacturing Co.

28A Methane Purification Process Plants. Low-temperature processing plants, designed and built by Air Products, Inc., produce methane containing less than 100 p.p.m. of other hydrocarbons.

29A Chromium Stainless Steels. G. O. Carlson, Inc., has large stock of Types 405, 410, and 430 chromium stainless plate available for quick delivery.

31A Data Sheets on Gas Drying. Give technical details on performance of "molecular sieve" adsorbents. Linde Co., Division of Union Carbide Corp.

32A-33A Asbestos Insulation Booklet. "Thermobestos" insulation, product of Johns-Manville, is available in pipe insulation form in sizes up to 30 in. O.D. Also in blocks in full range of thicknesses.

34L Portable High Efficiency Muller. Particularly adapted for pilot plants and small production requirements. Free mixing report on your product offered by Simpson Mix-Muller Division, National Engineering Co.

35A-36A Industrial Product Bulletins. U. S. Industrial Chemicals Co. offers bulletins on sodium dispersions, zirconium and hafnium application, and fabrication techniques, other new developments.

37A Non-Lubricated Plug Valves. Full range of valve materials and special plug facings available. Technical details from DeZurik Corp.

39A Bulk Material Conveying Systems. Feeders, conveyors, elevators, screens, hoists. Bulletins from Stephens-Adamson Manufacturing Co.

40TL Chlorinator Bulletin. W&T V-notch chlorinators, product of Wallace & Tiernan, Inc., are rugged, easy to operate, and moderately priced.

40BL Chlorine Detector. Will detect as little as 3 p.p.m. chlorine in a continuous air-stream sample. Bulletin from Wallace & Tiernan.

41A Fume Scrubber Bulletin. Describes equipment in wide range of sizes in cast iron, steel, Haveg, stoneware, rubber, or PVC-lined, or in other synthetic materials. Schutte and Koerting Co.

42A-43A Process Plant Design and Construction. Large butadiene plant for Firestone completed by Catalytic Construction Co. in less than nine months in the field.

44L Metallic Filter Cloth Catalog. All weaves, all metals, for all types of processing service. Newark Wire Cloth Co.

45A Mercury Arc Rectifiers. Factory-packaged units cut installation costs and time. Sealed tube rectifiers supplied in completely enclosed or open types. Allis-Chalmers.

46L Motor Pump Bulletin. Sizes ¼ to 75 hp., capacities to 2,800 gal./min., heads to 650 feet. Complete information from Ingersoll-Rand.

47A Magnetic Flow Meter. No erosion, no fouling. Flow measurements picked up electrically by flush-mounted electrodes. Accurate to one per cent of full scale. Technical details from Foxboro Co.

> ○ **CHECK** *your Data Service requests on the handy postcard on page 66 to*
>
> ▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

48A Non-Pressurized Heat Transfer Fluid. "Aroclor," non-pressurized, liquid-phase heat transfer fluid, does not support combustion up to its boiling range, 652 to 725° F. Non-corrosive. Technical information from Monsanto Chemical Co.

50A Cooling Tower Packing. "Poly-Grid" packing, product of the Fluor Products Co., is available in high-impact polystyrene or linear polyethylene.

312A Nozzle-Type Safety Relief Valves. Wide range of orifice sizes, and with inlet sizes from 1 to 8 in. Bulletin from Crosby Valve & Gage Co.

51A Processing Reagents. "Syloids," made by Davison Chemical Co., act as flatting agents for vinyls, lacquers and varnishes, as thickening agents for resins and inks, many other uses. Technical literature.

53A Process Valves. Bronze, iron, steel, and corrosion-resistant valves to fit every chemical processing need. Wm. Powell Co.

54L Heat Exchangers. For high operating pressures, severe temperature conditions, thermal shock "Heliflow" exchangers are made by Graham Manufacturing Co.

(Continued on page 72)

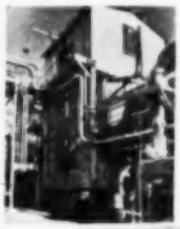
Spray Drying is the modern labor-saving process used to produce products with greater sales appeal, often at reduced production costs. Numerous processes in use today are subject to the same modernization as has been applied, with Bowen cooperation, in many leading industries:

Electronic industry benefits by a high quality finely blended homogenous Titania material which is easily extruded for special dielectric parts . . .



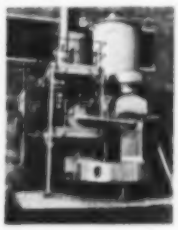
FIRST SPRAY DRIED BY
American Lava

Evaporation loss of crude oil can now be reduced by 80-90 per cent with nitrogen-filled microscopic phenolic spheres which form vapor seal on stored crude oil . . .



FIRST SPRAY DRIED BY
Bakelite

New sterile Plasma Volume Expander for intravenous injections has saved countless lives in both military and civilian use . . .



FIRST SPRAY DRIED BY
Commercial Solvents

Developing New Products on Bowen SPRAY DRYERS

Patented Bowen air cooling features made possible the large production of thermoplastic and thermosetting resin powders . . .



FIRST SPRAY DRIED BY
Plaskon

Controlled spherical shape, free-flowing characteristics and high density of spray dried Ferrites, makes possible superior performance of electrical cores . . .



FIRST SPRAY DRIED BY
Stackpole Carbon

And, many other companies with whom Bowen has worked have pioneered with Bowen Equipment to produce a FIRST-of-its-kind product. Bowen engineers are available to work with you to incorporate Spray Drying in the production of your products. Whether you are producing a high cost quality product or a basic material in quantity where low cost is the determining factor, you should investigate Spray Drying.



Write for this Interesting Book

THE BOWEN LABORATORY SPRAY DRYER

We will be glad to send it — No obligation

BOWEN ENGINEERING, INC.
NORTH BRANCH 13, NEW JERSEY

BOWEN SPRAY DRYERS
Always Offer You More!

Recognized Leader in Spray Dryer Engineering Since 1926

EQUIPMENT (Cont.)

314 Nuclear Filtration Equipment. Cuno Engineering Corp. offers new folder covering complete line of filters and filtration systems for use in nuclear power and research applications.

315 Screw Pumps. Bulletin features double external bearing and gear type, and double external bearing and gear hopper type. Warren Pumps, Inc.

316 Pressure Regulator Bulletin. Bulletin with size and capacity information from Watts Regulator Co. For steam and air service.

317 Semi-Steel Valve Bulletin. Covers straightway and multiport types, locking devices, wrenches, lubricants. 48 pages. Rockwell Manufacturing Co.

318 Local Mounted Temperature Controls. 13-page bulletin from United Electric Controls Co. discusses theory, gives general specifications, dimensions, ordering information.

319 High Temperature Gas Chromatograph. For quick and accurate analysis of gases and liquids with boiling points up to 350° C. Complete technical details in bulletin from Scientific Instruments Division, Beckman Instruments, Inc.

320 Contact Motor-Relays. Description and circuitry, ordering information and prices contained in 40-page catalog from Assembly Products, Inc. Includes auxiliary control components and panel meters.

321 Diaphragm Valves. 12-page catalog from Hills-McCanna Co. includes quick reference chart for diaphragm material selection and dimensional specifications for several valve models.

322 Comprehensive Cooling Tower Bulletin. New 32-page bulletin from Foster Wheeler Corp. describes induced-draft counterflow cooling tower. Photos, drawings and charts.

323 Motor-Driven Compressor Catalog. 44-page engineering catalog "Industrial Air" offered by Cooper-Bessemer Corp. Capacities, specifications, typical data for industrial air requirements from 200 to 2,000 hp.

324 Differential Pressure Switch. Model 211 indicating switch is suitable for measuring low differential range at high static pressure. All units are responsive to small pressure differentials. Bulletin from Barton Instrument Corp.

325 Welded Polyethylene Ducting Systems. Reprint of article describes use in handling of alkali and acid fumes. Photographs and charts. American Agile Corp.

326 High Capacity Compressor. New, compact 200 hp. compressor, displacement 1,150 cu.ft./min., fits in 72 in. by 68 in. space. Complete specifications from Gardner-Denver Co.

327 Graphite Entrainment Separator. Four-page bulletin from National Carbon Co. gives tables of separation efficiencies, unit dimensions, working pressures, and entrained liquid capacities for six sizes of separators.

328 Adjustable Stroke Diaphragm Pump. Capacities to 70 gal./min. for simplex and 140 gal./min. for duplex pumps at ¾ to 1 hp., depending on specific gravity of pulp. Technical details from Denver Equipment Co.

329 High-Vacuum Equipment Catalog. Complete technical details on high-vacuum pumps, valves, gauges, etc., 22 pages. Consolidated Electrodynamics Corp.

330 Belt-Driven Duct Fan. Designed to operate under corrosive atmospheres and extreme temperature ranges. Available in sizes from 12 to 72 in. Chicago Blower Corp.

331 High-Capacity Screen. Bulletin from Dorr-Oliver. Available in four standard sizes from 1 to 4 ft. in width. High efficiency in the 8-48 mesh range.

MATERIALS

357 High Purity Cresylics. Bulletin from Pitt-Consol Chemical Co. gives properties of phenol, cresols, cresylic acids, xylenols, phenolic resins, molding powders.

358 Neoprene Coatings Selection Data. Atlas Mineral Products Co. offers comprehensive chart showing resistance of neoprene coatings to wide variety of inorganic and organic chemicals.

359 Lithium Booklet. 15-page booklet from American Lithium Institute describes properties, uses, research potentials, and availability of lithium and its compounds.

360 Mineral Wool Pipe Insulation. "Mono-Kover," a slit, one-piece, sectional type molded mineral wool pipe insulation, is lightweight, flexible, easy to apply. Bulletin from Baldwin-Hill Co.

361 Butyl Rubber Resistance Data. 16-page booklet from Thiokol Chemical Corp. gives quick reference charts and tables showing reaction of Butyl to hydrocarbons, corrosive solutions, and halogen gases.

362 Molybdenum Disulfide Lubricants. Physical and chemical properties, catalog-type selection table, discussion of bonded solid film lubricating coatings. Bulletin from Alpha Molykote Corp.

363 Glacial Methacrylic Acid Booklet. Properties, uses, reactions described in detail in 17-page brochure from Rohm & Haas Co.

364 Stainless Steel Product Data. More than 20 tables, including corrosion resistance of various stainless steels, fabricating properties, weight per lineal foot in various widths and gauges. 32-page booklet from Allegheny Ludlum Steel Corp.

365 Asbestos Textile Reference Manual. Technical data to enable engineer to select asbestos textiles for any application or temperature range. Union Asbestos & Rubber Co.

366 Cooling Tower Corrosion Inhibitors. Technical data sheet from National Aluminate Corp. describes principal uses, properties, gives shipping and handling information.

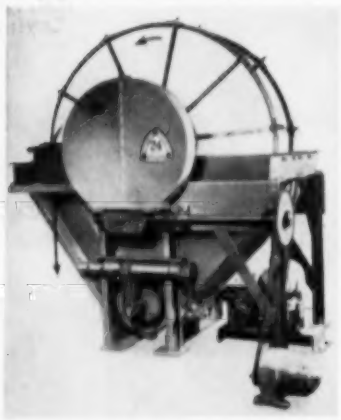
367 Glutaraldehyde (Pentanedial). Properties, shipping data, industrial applications, reactions, and physiological properties discussed in technical bulletin from Union Carbide Chemicals Co.

368 Corrosion Inhibitors in Oil Production. Booklet "Armour Organics for Increased Oil Production" covers application of polar cationic chemicals in both primary and secondary oil production. Armour and Co., Chemical Division.

369 Teflon Rods. Teflon extruded and molded rods are recommended for bearings, bushings, gaskets, packings, pump and valve components, rings, discs, etc. Technical data from U. S. Gasket Co., Plastics Division of Garlock Packing Co.

(Continued on page 72)

DEVELOPMENTS OF THE MONTH (Cont.)



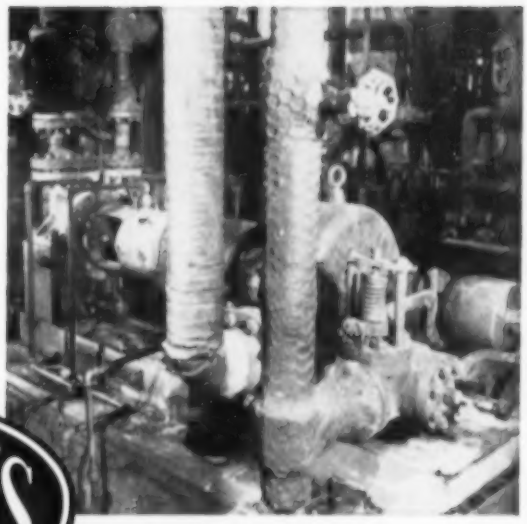
396 Agitator Type Disc Filter. New type disc filter, using no packing gland or sealing water, said to give increased filter capacity and ease of maintenance. Pulp agitation is supplied by a pulsating unit located below filter discs. Design and location of agitation mechanism provides correct agitation to keep solids in pulp in suspension; agitation speed is adjustable to maintain a homogeneous pulp.

The agitator mechanism is easily removable for service as a unit; packing gland, sealing water, and bearings in the tank have been eliminated, thus making maintenance problems negligible.

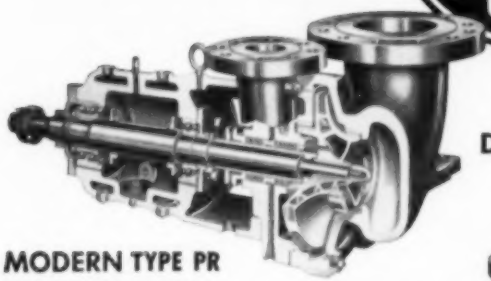
The new feature is available on all sizes of disc filters made by the Denver Equipment Co. who offer complete technical information. Circle number 396 on Data Post Card.

(Continued on page 72)

GET THE Modern Design OF PEERLESS PUMPS... FOR Dependable Pumping OF REFINERY PROCESS LIQUIDS

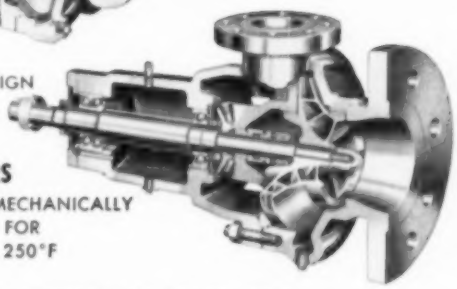


PEERLESS PUMP



Modern TOP AND END SUCTION *and* TOP DISCHARGE DESIGNS IN BOTH TYPES FOR CONTINUOUS DUTY SERVICE IN MODERN REFINING PROCESSES

MODERN TYPE PR
CENTER-LINE MOUNT
PACKING GLAND PUMP DESIGN
FOR TEMPERATURES
UP TO 850°F



MODERN TYPE PRS
CENTER-LINE MOUNT MECHANICALLY
SEALED PUMP DESIGN FOR
TEMPERATURES UP TO 250°F

USE THE HORIZONTAL TYPE PR PUMP WHERE YOUR APPLICATION REQUIREMENTS ARE: Rugged Center-Line-Mount Construction; High Temperatures; High Pressures; High Capacity; Extra Low NPSH Requirements; Optional Use of Mechanical Shaft Seal or Packing Gland Construction; End or Top Suction Design; Dependable Performance with Minimum Maintenance; Availability in Various Alloys; A Complete Range of Sizes; Many Sizes Available from Stock in Standard Materials; Maximum Parts Interchangeability; Wide Range of Liquid Pumping Services, such as Hot Oil, Butane, Propane, Hydrocarbons, Hard-to-Handle Chemicals and Water. For descriptive Bulletin check and mail coupon.

TYPE PR PUMPS ARE A LINE OF PACKING GLAND AND MECHANICALLY SEALED PROCESS PUMPS with these Specifications —

Capacities: up to 1200 gpm.

Operating Heads: up to 675 feet.

Temperatures: Type PR (Packing gland construction) up to 850°F; Type PRS (Mechanical Shaft Seal Construction) up to 250°F.

Case Pressures: up to 600 psi.

Drives: horizontal electric motor is standard; others as required, such as steam turbine drive or stationary engine drive.

Materials of Construction: Liquid end can be furnished in cast iron, bronze, carbon steel, stainless steel or other materials as required for intended service.

Liquids Handled: hot oil, hot water, propane, butane and all petroleum hydrocarbons, process liquids, Dowtherm, and numerous other solutions.

NPSH Characteristics: designed to operate with minimum available NPSH.

PEERLESS PUMP DIVISION
FOOD MACHINERY AND CHEMICAL CORPORATION

Factories: Los Angeles, Calif. and Indianapolis, Indiana.
Offices: New York, Atlanta, Chicago, San Francisco, St. Louis, Phoenix, Fresno, Los Angeles; Plainview and Lubbock, Texas; Albuquerque, New Mexico.
Distributors in Principal Cities; Consult your Telephone Directory.

PEERLESS PUMP

fmc

MAIL COUPON FOR BULLETIN

PEERLESS PUMP DIVISION CEP
Food Machinery and Chemical Corporation
301 West Avenue 26
Los Angeles 31, California

Please send us copy of Peerless Type PR Pump Bulletin No. B-1605.

NAME_____

COMPANY_____

STREET_____

CITY_____ STATE_____

MATERIALS (*Cont.*)

370 Plastic Pipe Catalog. Covers development, application, installation, and specifications of SP plastic pipe made from new-type polyethylene resin. Orangeburg Manufacturing Co.

371 New Plastic Construction Material. "Rigiply," product of Heil Process Equipment Corp., is a fiber glass-reinforced laminate of thermosetting resins said to have superior resistance to acids and alkalis. Technical literature.

372 Tank Corrosion Data. Series of short articles on corrosion—particularly as it affects storage tanks and similar facilities. Also extensive tank calibration tables. Gates Rubber Co., Industrial Division.

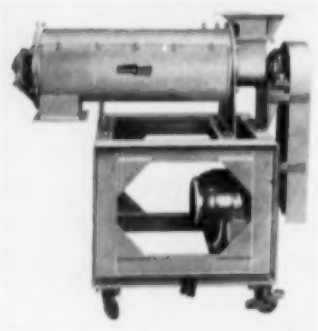
373 Foamglas Insulation Application Specifications. Set of six specifications gives suggested thicknesses, detail drawings, insulation supports, and recommended finishes. Pittsburgh Corning Corp.

374 Copper & Copper-Alloy Specifications Index. 28-page booklet from American Brass Co. lists standards, specifications, chemical compositions.

375 New Adhesives Additive. Technical publication gives comparative penetration evaluations, typical formulations, new test procedures for tack development. Minerals & Chemicals Corp. of America.

376 High-Temperature Corrosion Data. Data sheet from Babcock & Wilcox Co. gives latest data on B&W Croloy 18-8 Ti (AIS Type 321).

DEVELOPMENTS OF THE MONTH (*Cont.*)



397 High Speed Mixer. A precision mixer for uniform, fine-finish mixing. Particularly suitable for disintegrating fat pellets, chemical ingredients that have a tendency to ball or agglomerate, or other ingredients which can be broken by the paddles and thoroughly dispersed in the mixture. Also recommended where a fluffing action is desired on powdered materials or when it is desired to add minor percentages of liquids. Adjustable-pitch paddles control the output capacity up to 10,000 lb./hr. Precision machining of the interior affords close tolerance operation between paddle tips and chamber wall and makes the mixer practically self-cleaning. Normally, a 10 hp. motor provides all necessary power, but the "Turbulizer" will accommodate up to 20 hp. to handle difficult materials. Units are built of carbon or stainless steel and may be jacketed for heating or cooling. Strong-Scott Manufacturing Co. Circle number 397 on Data Post Card.

(Continued on page 74)

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

55A Heavy-Duty Process Pumps. High heads at normal or elevated temperatures. Also valves, filters, and other equipment to handle corrosive solutions. Technical data from Duriron Co.

56L Silicone Coatings. Heat resistance up to 800° F. "Sicon" coatings, made by Midland Industrial Finishes Co., are easy to apply by brush, spray, or dip.

57A Heavy-Duty Filters. The Sparkler MCR, product of the Sparkler Manufacturing Co., is engineered for low cost, fast cleaning, minimum of down time.

59A Custom-Built Processing Equipment. Consulting services available from the Sun Shipbuilding & Dry Dock Co.

61A Valve Case-History Book. Crane Co. offers booklet covering 32 illustrated case histories on valve installations throughout industry.

62L Sub-Micron Filters. "ClaRite" filters will eliminate particles down to 1/10 micron with excellent flow rates. Available in carbon steel, stainless, or lined carbon steel. Details from Croll-Reynolds Engineering Co.

63A Engineering and Construction Services. Badger Manufacturing Co. uses new processing concept to make styrene directly from gasoline. Brochure.

64A Steel Tanks and Plate Work. Most advanced welding, X-ray testing, stress-relieving and assembly methods. Graver Tank & Manufacturing Co.

69A Spray Drying Booklet. Bowen Engineering, Inc. specializes in spray dryers for all types of chemical processing.

71A Pump Bulletin. Top and end suction and top discharge designs for continuous duty service in modern refining processes. Peerless Pump Division, Food Machinery and Chemical Corp.

(Continued on page 74)

○ **CIRCLE** *your Data Service requests on the handy postcard on page 66 to*

▶ **GET** *up-to-the-minute catalogs, data sheets and bulletins on new chemical products, processes and equipment.*

377 Silicone Insulation for Motors. Gives protection against overloads, moisture, high ambient temperatures, rapid reversing, corrosion. Bulletin from Dow Corning Corp.

378 Chemical-Resistant Lining. 18-page booklet from Dow Chemical Co. gives properties, materials, etc., of "Saraloy 898," flexible thermoplastic lining for tanks, pipe and fittings, fume ducts and hoods.

379 Corrosion-Resistant Materials. General Ceramics Corp. offers bulletin on porcelain, stoneware, alumina, "Chemplas 15," and graphite equipment.

380 Refractory Cement. Brochure from Refractory & Insulation Corp. gives technical data on "Super #3,000" refractory cement for bonding, patching and lining.

381 Chemical Products Catalog. Description, properties, applications of about 70 chemicals marketed by American Potash & Chemical Corp. Includes information on newer lithium and boron compounds.

382 Underground Pipe Insulation. "Tri-Sulite," made of granulated gilsonite, forms three zones of permanent protection. Details in bulletin from G. S. Ziegler & Co.

383 Chemical Product Catalog. Specifications, properties, shipping information on aliphatic chemicals, aromatic chemicals, cellulose products, inorganic chemicals. Eastman Chemical Products, Inc.

384 Teflon Lined Steel Pipe. For temperatures up to 400° F. and pressures to 300 lb./sq. in. Haveg Industries, Inc.

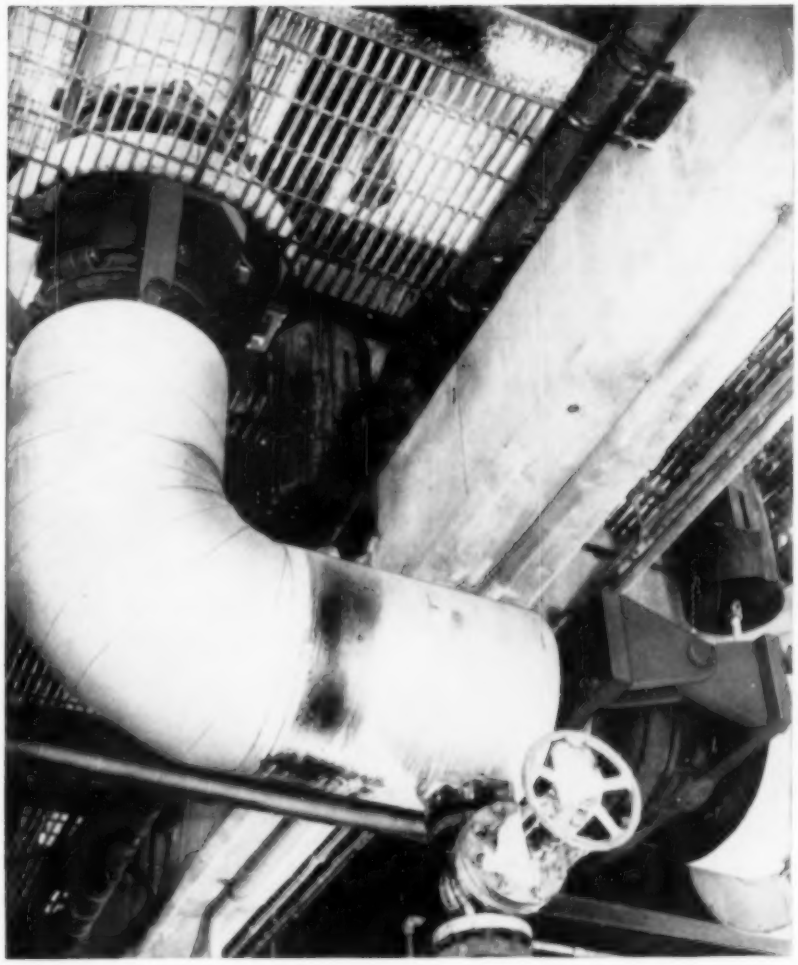
SERVICES

385 Book on Pulp Bleaching. Comprehensive 60-page book from Hooker Electrochemical Co. contains process flow sheets, equipment diagrams, many graphs.

386 Data Processing Services. Scientific computing, data processing, data reduction, consultation services for science and industry. The Datics Corp. Bulletin.

387 Hazard Finder. Illustrated folder contains check list of questions to determine whether hazardous conditions exist in your plant. Crouse Hinds Co.

388 Sulfuric Acid Plant Design and Construction. Chemical Construction Corp. has been building contact sulfuric acid plants since 1924.



THIS IS WHAT

ADSCO

MEANS BY

SPECIAL

JOINTS

The photo shows a small but very important section of an insulated, spring-suspended 8" pipe line in the new Moundsville, W. Va., plant of the National Aniline Division of Allied Chemical & Dye Corp. At the point shown, the line is subjected to complex stresses which are completely resolved and placed in balance by the ADSCO Gimbal Expansion Joint, upper left, and the ADSCO Hinge Expansion Joint, lower right.

In the Gimbal Joint, two sets of bars are pinned to the octagonal ring at 90° to each other. The other ends of the bars, still at 90° to each other, are pinned to the pipe leading into the joint. Running through the center of the ring, with a slight clearance, is a nipple connecting two expansion elements. This gimbal arrangement permits the joint to absorb 6° of angular movement from two different directions: the left and right motion of the horizontal part of the ell and similar motion from other unseen upper horizontal piping at 90° to the plane of the lower piping.

A partner to the Gimbal Joint and an indispensable part of this piping system is the Hinge Joint shown lower right. This absorbs the angular rotation of the ell caused by the expansion and contraction of the vertical piping.

There are so many motions involved in this section that, under certain conditions, the octagonal ring of the Gimbal Joint could describe a circle. Yet ADSCO and National Aniline engineers were able to identify all the motions and absorb them economically and efficiently by the Gimbal and Hinge Joints.

ADSCO designs and manufactures many types of both standard and special joints for many purposes. Consult ADSCO on any piping problem.

ADSCO DIVISION
YUBA INDUSTRIES, INC.
20 MILBURN ST. BUFFALO 12, N. Y.

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

73A Special Piping Joints. Adsco gimbal and hinge expansion joints can solve many unusual piping problems. Details from Adsco Division, Yuba Industries, Inc.

75A Batch Filter Bulletins. Technical details on vertical leaf, vertical batch, horizontal leaf, and cartridge filters from Process Filters, Inc.

77A Package Oil Heating Systems. Whitlock Manufacturing Co. offers standard "packages" including heating unit, operating controls, and expansion tank to heat chemically-stable transfer oils. Technical data and prices from manufacturer.

79A Compressor Bulletins. Cooper-Bessemer packaged industrial air compressors are available in three basic types from 200 to 2,000 hp.

81A High-Pressure Reactor Article. Autoclave Engineers offer reprint of article on operation and performance of bench-scale, high-pressure reactors.

82L Inert Gas Generators. A compact, economical source of inert gases. Capacities up to 35,000 std. cu. ft./hr. Larger units custom-built. Bulletin from Thermal Research & Engineering Corp.

83R Safety Heads and Rupture Discs. Consulting services on pressurized systems available from Black, Sivalls & Bryson, Inc.

84L Heat Transfer Equipment. Materials purchased to rigid specifications, standard components carried in stock. Technical data from Doyle & Roth Manufacturing Co.

85A Leakproof Pumps. Pump and motor in single, leakproof unit. No shaft sealing device required. Details from Chempump Corp.

86L Cost Estimation Data for Graphite Equipment. 32-page report presents costs and equipment specifications on standard impervious graphite equipment produced by Falls Industries, Inc.

87A Consulting Service on Dryers. Free analysis and recommendations on your drying problem are offered by Louisville Drying Machinery Unit, General American Transportation Corp.

88L Dry Blender Bulletin. Folder from Paul O. Abbe, Inc., describes the "Rota-Cone" blender, available in sizes from 9 to 120 in. in diameter, capacities from 1 gallon to 325 cu. ft.

89A Glassed Steel Conical Dryer-Blenders. Data sheet from Pfaudler Co. describes units up to 165 cu. ft. working capacity. Loan units also available.

90L Chemical Pump Data Summary. Bulletin from Lawrence Pumps, Inc., gives summary of acid and chemical pump data based on Lawrence propeller and axial flow pumps.

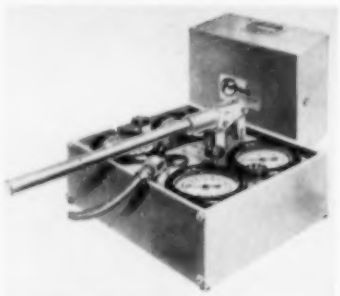
91A Engineering and Construction Services. Plants for the chemical processing industry. Fluor Corp.

92L Spray Nozzle Catalog. 30-page catalog describes complete selection of standard nozzles available from Spray Engineering Co.

93A Impervious Graphite Equipment Data. Catalogs available from National Carbon Co. give technical data on "Karbate" pumps and equipment, activated carbon, carbon bricks.

95A Sealless Pumps. No stuffing box or mechanical seal, self-priming, high vacuum. Complete technical details from Vanton Pump and Equipment Corp.

DEVELOPMENTS OF THE MONTH (*Cont.*)



39B Portable Hydrostatic Testing Unit. The Porta-Tester," made by the Farris Engineering Corp., is designed for on-the-site testing of valves, pressure vessels, piping, steam generators, pump cases, and other process equipment. Operated at pressures up to 3,000 lb./sq. in. Unit measures 18 in. x 14 in. x 8 in. and can be carried easily. It is supplied complete with four test-accuracy gauges and eight feet of hydraulic, flexible tubing. The unit is suitable for use with water or other hydraulic fluids. Complete information is available from the manufacturer. Circle number 398 on Data Post Card.

(Continued on page 76)

96L Centrifugal Pump Specifications. The Eastern D-11 centrifugal pump is available in many materials, in capacities up to 70 gal./min., pressures to 65 lb./sq. in. Bulletin. Eastern Industries, Inc.

97A Granular Carbon Booklet. Brochure "Pittsburgh Activated Carbons" describes types and uses in vapor and liquid phase applications. Pittsburgh Coke & Chemical Co.

98L Filtration Analysis Report. Eaton-Dikeman Co. offers free filter paper samples for test runs in your own plant.

99A Ethylene Oxide Plant Design and Construction. Three new plants under construction by the Lummus Co. will be first to use Shell Development Co.'s direct oxidation process.

100A Chemical Transportation Barges. Ingalls Shipbuilding Corp. specializes in construction of economical, practical barges for transportation of chemical products.

101R Vertical Process Pumps. Brochure from Layne & Bowler Pump Co. describes advantages of "Verti-Line" process pumps in chemical plant applications.

102L After-cooler Systems. The Niagara "Aero" after-cooler is self-contained, independent of large supply of cooling water. Bulletin from Niagara Blower Co.

103A Low-Temperature Stainless Steels. Booklet "Properties of Stainless Steel at Low Temperatures" offered by International Nickel Co.

104A Heat Exchanger Data and Prices. Standard equipment in stock in sizes from 20 to 300 sq. ft. of surface including fixed tube sheet, floating, and U-tube units. Struthers Wells Corp.

108A Tower Packing Booklet. Physical and chemical data on wide variety of tower packings. U. S. Stoneware Co.

109R High-Pressure Needle Valves. Big or small high-pressure needle valves for refineries and chemical plants. Bulletin from August Spindler & Sons, Inc.

110L Swing Joint and Assembly Catalog. Single swing, double swing, and counterbalance styles and assemblies to meet every need. Barco Manufacturing Co.

111A "Valveless" Filter. Bulletin "The Permutit Valveless Filter" gives details, drawings, operating conditions, capacities of completely automatic gravity filter. Permutit Co.

112L New Chemical Faucet. For flammable and corrosive fluids. Details from Eco Engineering Division, Economy Faucet Co.

113A Controlled Volume Pump Bulletin. Typical applications, flow charts, description, and specifications of controlled-volume chemical pump. Lapp Insulator Co., Process Equipment Division.

114L Wire Conveyor Belt Reference Manual. 130-page manual from Cambridge Wire Cloth Co.

115A Clarifier Bulletin. Bulletin from Centrico, Inc., describes use of the Westfalia KG clarifier in the chemical industries.

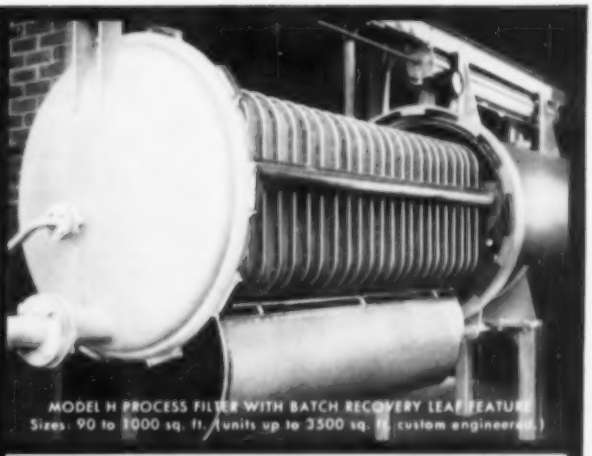
116L Chemical Gaskets and Accessories. Expansion joints and flexible couplings, jacketed gaskets, reducers. Catalogs from United States Gasket Co.

117A Centrifugal Pumps. Complete line of single and multi-stage centrifugal pumps in both horizontal and vertical designs. Technical information from Ingersoll-Rand.

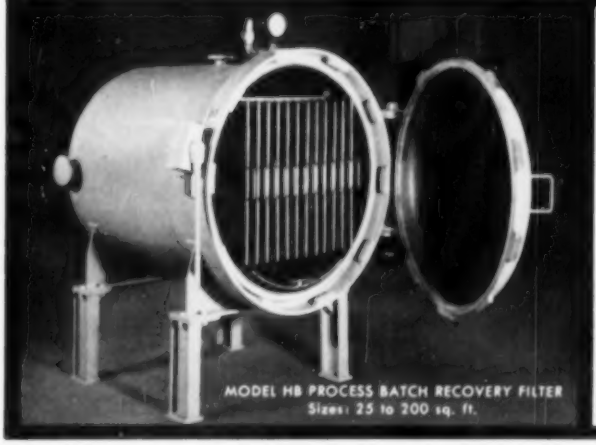
119A Equipment Fabrication. Koven Fabricators, Inc. are specialists in intricate fab-

(Continued on page 76)

when is a filter truly a batch filter?



MODEL H PROCESS FILTER WITH BATCH RECOVERY LEAF FEATURE
Sizes: 90 to 3000 sq. ft. (units up to 3500 sq. ft. custom engineered)



MODEL HB PROCESS BATCH RECOVERY FILTER
Sizes: 25 to 200 sq. ft.

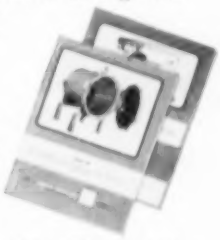
the PF answer:

when it filters
a complete preparation
down to the last drop!

That's exactly what these PF Filters are equipped to do. Especially designed for large and small batch filtering operations, they can be profitably utilized in continuous processes which involve a wide variety of liquid and solid separations. Processors who change products, formula and treatment will find that PF Batch Recovery Filters provide multiple advantages.

THERE'S NO WASTE — NO NEED FOR STORAGE! Featuring separately piped recovery leaves, PF Batch Filters are outfitted to handle unfiltered residue remaining in the tank at the end of the regular filtration cycle. The residue is filtered via blow-down rapidly down to practically the last drop in approximately the same time it would take to blow it back to a storage area . . . *and with less loss of residue.*

AND WHEN IT COMES TO PRODUCTIVITY . . . You can count on a PF Filter to boost your output in more ways than one. Start-up reports prove the point. For example: A 40 sq. ft. Process Model HB Filter clocked 1¾ hrs. in filtering a 2500 gallon batch — actually doing the job in less time than a 160 sq. ft. plate and frame filter. Residue remaining in the tank at the end of the regular filtration cycle was blown through the recovery leaf in five minutes. Cake discharge took 8 minutes.



LIKE MORE FACTS? Illustrated Bulletins, describing the Model HB and the Model H with Batch Recovery Leaf Feature, are yours for the asking. Write.

PROCESS FILTERS, INC. (A subsidiary of Bowser, Inc.)
1807 Elmwood Ave., Buffalo 7, N. Y.

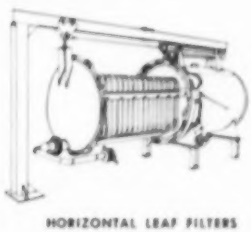
pf



VERTICAL LEAF FILTERS



VERTICAL BATCH FILTERS



HORIZONTAL LEAF FILTERS



CARTRIDGE FILTERS

PRODUCTS ADVERTISED IN THIS ISSUE (*Cont.*)

rication using stainless steel, aluminum, Monel, nickel, Inconel, all clad materials. Bulletin.

120L Vaporizers. Several types to suit refinery or chemical plant needs. Richard M. Armstrong Co. invites inquiries.

121A Bulletin on Industrial Catalysts. For hydrogenation, synthesis gases and hydrogen generation, desulfurization, new catalytic processes. Girdler Co., Catalyst Dept.

122L Chemical Mixers. In iron, steel, or alloys. Can be built for vacuum operation. Particularly suited for drying heat-sensitive materials. Consulting services available from Baker Perkins, Inc.

123A Chemical Process Pumps. Full technical information from the Aldrich Pump Co.

124L Tray Dryers. Completely automatic operation with simple changeover to manual for small test or research runs. Technical details from C. G. Sargent's Sons Corp.

125A Control Valves. Low initial cost and low maintenance and spare parts inventory. Annin Co.

126TL Germanium-Selenium Rectifiers. Custom-engineered but priced to compete with mass-produced equipment. Details from Sel-Rex Corp.

126BL Adjustable Sprocket Rim. Furnished with chain guide to reach all overhead valves without danger. Descriptive catalog sheet and prices. Babbitt Steam Specialty Co.

127A Plant Design and Construction. Brochure from the Girdler Co. describes engineering services available from their Gas Processes Division.

128L Oil Reclaimer Systems. To remove solids, sludge, acid, moisture, solvents, and dissolved gases and to restore viscosity and dielectric strength. Details in bulletin from Hilliard Corp.

129A Vinyl Resins. Complete line of vinyls engineered to specific processing needs. Information and technical service from Firestone Plastics Co., Chemical Sales Division.

130BL Industrial Irritant Protection. "Kerodex," product of Ayerst Laboratories, protects hands from acids, alkalis, solvents, paints, cutting oils, and resins.

131A Atomic Testing Reactors. Blaw-Knox Co. has played a prominent role in the development of test reactor facilities.

132TL Industrial Desiccants. "Florite" absorbs water instantly from gases and liquids in either a static or flowing system. Floridin Co.

132BL Thermal Precipitation Instruments. For precise dust determinations. Three models employing continuous oscillating or gravimetric methods. Joseph B. Ficklen, 3rd.

133R Corrosion-Resistant Filter Bulletin. Adams CFR or CVF filters are available rubber-lined or in carbon steel, stainless, Monel, and nickel. R. P. Adams Co.

134BL Polyethylene Laboratory Ware. Descriptive folder from Ace Glass, Inc.

135A Filters. Eimco Corp. offers technical details on wide range of filter designs for the chemical processing industry.

136TL Fused Silica and Quartz Data File. Standard apparatus, crucibles, trays, cylindrical containers, and tubing available for early delivery. Amersil Co.

136BL Heat Exchange and Process Equipment. Condensers, evaporators, kettles, mixers, reactors, pressure vessels, heat exchangers. Manning & Lewis Engineering Co.

137L Plastic Ventilating and Exhaust Systems. Plastic exhaust and ventilating systems are recommended wherever corrosive fumes must be handled. Full details from American Agile Corp.

137R Filtration Catalog. Complete specifications to help in planning new filtration facilities. D. R. Sperry & Co.

138BL Rotameter Bulletin. Gives complete technical details of line of rotameters and flow indicators. Schutte and Koerting Co.

139A Heat Transfer Equipment. Ribbon flight and rotary dryers, rotary kilns, air-quenching coolers, etc. Bulletin from Allis-Chalmers.

142L Electric Motors. In one compact power package a high-speed NEMA foot-mounted motor and a low-speed, double reduction gear transmission. Details from U. S. Electrical Motors.

143TR Pilot Plant Equipment. Edw. Renneburg & Sons Co. specialize in the design of versatile pilot plant units. Consulting services available.

143BR Centrifugal Pump Catalog. Describes full line of pumps to handle corrosive and abrasive fluids in 1 to 80 gal./min. range, at heads to 75 feet. Bart Manufacturing Corp.

144BL Equipment Design, Development and Fabrication. Expert services offered by the Artisan Metal Products, Inc.

145TL Spray Nozzle Catalog. Catalog from Spraying Systems Co. gives details of instruments and methods used to develop better spray nozzle performance.

145BL Welded Aluminum Tanks. For storage, pressure vessels, and processing equipment. R. D. Cole Manufacturing Co.

145TR Bulk Material Flow Unit. The "Bin-Flo," installed in hoppers, bins, chutes, restores flow characteristics to materials which tend to pack or bridge in storage. Uses small volume of air at low pressure. Detailed literature from Bin-Dicator Co.

145BR Precision-Bore Tubing. Available in Pyrex Brand, Vycor Brand, and most of the electronic glasses. Detailed catalog from Wilmad Glass Co.

146L Thermocouple Heads. Built to withstand temperatures up to 900° F. in continuous service. Technical data from Claud S. Gordon Co.

146R Water Treatment Systems. Modern ion exchange systems provide an effluent chemically equivalent to that obtained by multiple distillation. Illinois Water Treatment Co.

147A Horizontal Pressure Filters. Bulletin from Industrial Filter & Pump Mfg. Co. gives complete technical description.

148L Mechanical and Heat Transfer Equipment. Goslin-Birmingham Manufacturing Co. offers world-wide service including custom designing and foundry service.

148R Centrifugal Pump Bulletin. Sizes from 1 to 4 in. discharge openings, capacities from 50 to 700 gal./min., heads from 30 to 220 feet. Frederick Iron and Steel, Inc.

154TL Automatic Pyrometer Catalog. "Simplytrol" automatic pyrometers have 10 standard ranges from minus 200 to plus 3,000° F. Catalog from Assembly Products, Inc.

154BL Batch Mixers. 100 to 8,000 pounds per batch. H. C. Davis Sons' Mill Machinery Co.

155BL Contaminated Waste Disposal. Radioactive, explosive, other toxic materials and equipment handled by sea disposal. Crossroads Marine Disposal Corp.

155TR Vacuum Equipment. Steam-jet ejectors, condensers, other types of vacuum equipment. Jet-Vac Corp.

155BR Heating Coils. 52-page bulletin explains advantages of "Thermo-Panel" coils as opposed to pipe coils. Dean Thermo-Panel Coil Division, Dean Products, Inc.

IBC Controlled Volume Pumps. Bulletin "Controlled Volume Pumps in Process Instrumentation" offered by Milton Roy Co.

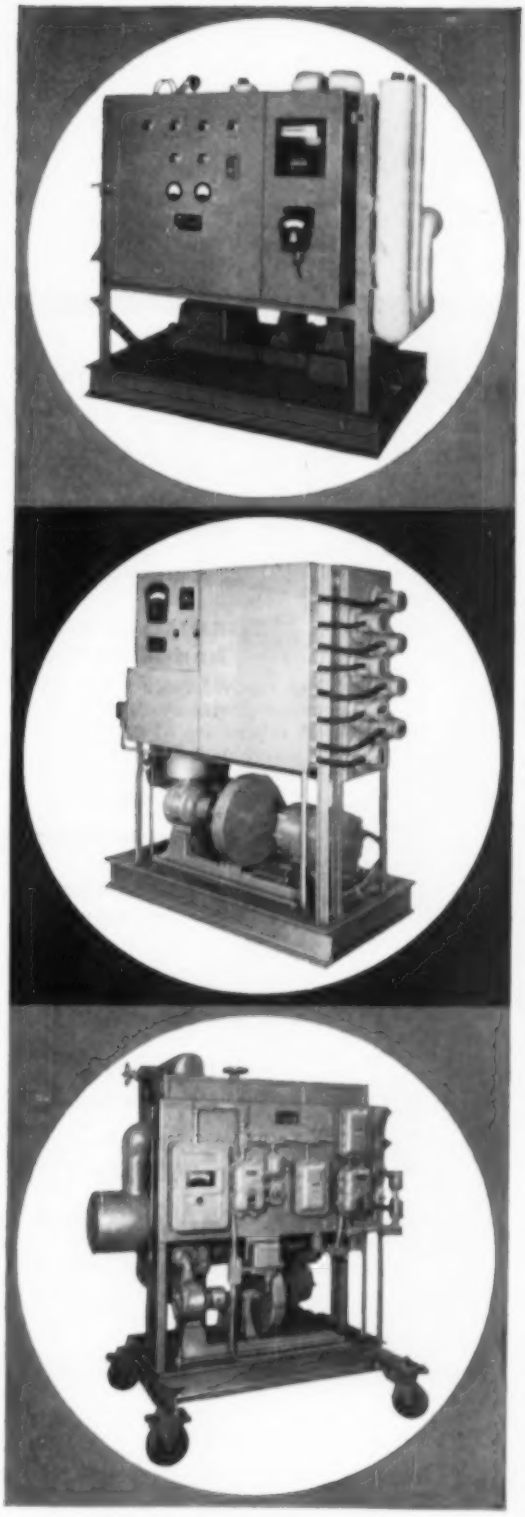
OBC Fluid Mixing Equipment. Mixing Equipment Co. offers quick, competent assistance on any fluid mixing problem.

DEVELOPMENTS OF THE MONTH (*Cont.*)



399 Industrial Filter Paper Work Book. An exhaustive compilation of data on all types of industrial filter papers. Includes a thorough discussion of the basic problem of solids-fluid separation, comparison charts, and ordering information. Technical data on all grades of Eaton-Dikeman filter paper include description, suggested applications, characteristics, and substance. Additional feature is a two-page application guide. Catalog also includes a glossary of industrial filtration terms. Consulting services are also available from the Eaton-Dikeman Co. Circle number 399 on Data Post Card.

Complete transfer oil heating systems in compact "packages"



WHITLOCK offers these standard "packages" including heating unit operating controls and expansion tank to heat chemically stable transfer oils. Since these oils are liquid over considerable temperature ranges, they are being used increasingly in chemical processing operations. The heating equipment, previously of special design, is now available as complete, standardized units to which only oil and electrical connections need be made to permit immediate operation.

The combination of low liquid pressures and high liquid temperatures eliminates the need for the application of high pressure design techniques to many current processes. In more and more installations these new "packages" are effectively serving to reduce overall equipment costs and simplify process design. The units are available in Standard, or Group 1 Class D Explosion-proof Constructions. Temperature controls are carefully selected to maintain the oil supply temperature within $\pm 2°$ F and the design precludes oil deterioration. Signal lights confirm satisfactory operation.

For additional information and prices write . . .

THE WHITLOCK MANUFACTURING COMPANY
97 South Street • West Hartford 10, Conn.

In Canada: Darling Bros., Ltd., Montreal

Whitlock

Designers and builders of bends, coils, condensers, coolers, heat exchangers, heaters, piping, pressure vessels, receivers, reboilers.

careers in the peaceful applications of atomic energy

SENIOR SCIENTISTS

Responsible positions: basic research in the *Physics of Solids*

THERMODYNAMICS and KINETICS

PhD or equiv. in either Physics or Chemistry. Supervise programs on thermal and thermodynamic properties of solids; stimulate work in Thermodynamics, Statistical Mechanics, and Rate Phenomena areas; guide experimental exploration of these fields.

ATOM ARRANGEMENTS —SOLIDS

PhD or equiv. in Physics, Chemistry or Metallurgy. Outstanding opportunity for senior man to direct research on solid structures. Actively stimulate studies of atom arrangement, by such means as electron or nuclear magnetic resonance, x-ray diffraction, electron microscope, etc.

Our reply will be prompt, confidential

ATOMICS INTERNATIONAL

A DIVISION OF NORTH AMERICAN AVIATION, INC.

Mr. G. W. Newton, Personnel Office, Dept. CEP-7,
21600 Vanowen Street, Canoga Park, California
(In the suburban San Fernando Valley, near Los Angeles)

MAJOR TEFLON RESIN EXPANSION

DuPont will expand production of all four of its commercial tetrafluoroethylene resins at its Parkersburg, W. Va., plant. Company will also design a plant to produce an experimental perfluorocarbon resin.

Plans now in the works at Du Pont's Washington Works call for increases in all four of its Teflon products. The granular powders, Teflon 1 and 5, will be increased by 30% by mid-1958. Construction already in progress will double production of the fine powder Teflon 6 and the aqueous dispersion Teflon 30. Plans for expansion will further increase these products by 30%.

New Perfluorocarbon Resin

At the same time the company has appropriated funds for an experimental plant to produce Teflon 100-X, a perfluorocarbon resin. The new material will have a melt viscosity low enough to permit extrusion in standard equipment. Small quantities of Teflon 100-X are now available at $19 a pound for experimental purposes. The new resin is expected to accelerate the development of applications not previously attempted because of processing difficulties.

The new resin shares the physical, electrical and thermal properties of Teflon resins but at temperatures of 400° F. instead of 500° F. The company is also considering the manufacture of film from Teflon 100-X.

Polyethylene pipe will be produced by the newly formed Evanite Plastic Co. subsidiary of Evans Pipe Co. Plant was recently purchased at Carrollton, Ohio. □

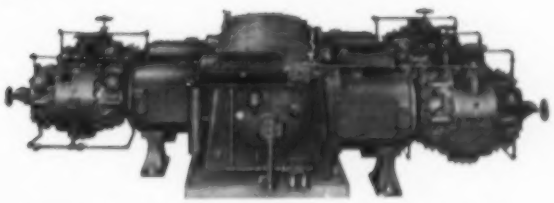
Heyward-Robinson Co. has recently enlarged its facilities to include construction as well as plant and process design in the chemical and industrial fields. □

American Smelting and Refining has bought all the oustanding stock of Enthone, Inc., New Haven, Conn., in exchange for shares of common stock of ASARCO. Enthone's products will supplement the products of ASARCO's Electrochemical department. □

Shieldalloy Corp. announces a new price of $16 a pound in maximum quantities for its metallic columbium. □

AIR FOR INDUSTRY

● Be sure to check on the *new* advantages in low-cost compressor service, packaged simplicity, extreme durability, easy installation and low maintenance, offered by one of America's *oldest* compressor builders. Write for descriptive bulletins . . . or phone Mount Vernon 82121.



Cooper-Bessemer packaged industrial air compressors are available in three basic types from 200 to 2000 hp.

Cooper Bessemer

GENERAL OFFICES:
MOUNT VERNON, OHIO

Engines: Gas • Diesel • Gas-Diesel
Compressors: Reciprocating and Centrifugal, Engine or Motor Driven

PYROCERAM

—THE CORNING GIANT

Harder than steel, lighter than aluminum, stronger than some metals, extremely corrosion-resistant at high temperatures, Pyroceram, new non-metallic crystalline material developed by Corning Glass Works, would seem to be the answer to an engineer's prayer.

Basic research on the properties of Corning's new Pyroceram has only just started. Many questions remain to be answered—what are its most logical industrial applications, when will it be available in commercial quantities, how much will it cost?

Table 2.—Pyroceram Materials—Chemical Durability

Reagent	Test condition	Weight loss (mg./cm.²) 8605	8606	8607	8608
5% HCl	24 hr./95° C.	2.5 to 5.6	0.7 to 1.07	0.05 to 0.06	0.00+ to 0.011
5% H_2SO_4	24 hr./95° C.				0.007 to 0.018
5% NaOH	6 hr./95° C.	0.21 to 0.36	0.72 to 0.93	0.67 to 0.86	1.26 to 1.53
N/50 Na_2CO_3	6 hr./95° C.			0.04 to 0.05	0.024 to 0.040

Note.—Weight losses from surfaces as fired were materially lower than those exposed by grinding. Ranges of above table will cover these differences under most conditions.

Applications

First large-scale application is the fabrication of nose cones for guided missiles. Here, the high-temperature stability plus the excellent abrasion properties of the Pyroceram materials may prove vital in our guided missile program, where attention has lately been centered on the "re-entry" problem, that is, the overcoming of the tremendous heat of friction engendered when a missile returns to the atmosphere after its flight through comparatively empty space.

In the chemical processing field, piping is expected to be one of the first large-scale applications. In particular, the fabrication of relatively large diameter pipe would seem to be indicated. The logic of this is twofold: in the first place, the increased strength of the new materials makes possible larger diameters and higher pressures than can presently be attained with glass pipe; in the second place, there would be no direct competition with glass pipe which is now made in diameters up to six inches.

"At present," says W. H. Tomb, manager of Corning's Plant Equipment Sales Dept., "Corning is engaged in a development program which is expected to lead to produc-

(Continued on page 82)

Table 1.—Comparison of Properties

	Pyroceram 8605 (Opaque)	8606 (Opaque)	8607 (Clear)	8608 (Opaque)	Glass Pyrex 7740	Ceramic Steatites $MgO \cdot SiO_2$	Metal Stainless steel type 302 annealed
Specific gravity room temp. (25° C.)	2.62	2.60	2.40	2.50	2.23	2.65 to 2.92	7.93
Water absorption (per cent)	0.00	0.00	0.00	0.00	0.00	0 to 0.03	—
Porosity (gas permeability)	Gas tight	Gas tight	Gas tight	Gas tight	Gas tight	—	—
THERMAL							
Softening temp. (°C.)	1350	1250			820	1349	—
Specific heat (25° C.)	0.185	0.190		0.190	0.186	—	0.118 (100° C)
Mean (25° C.-400° C.)	0.230	0.232		0.240	0.233	—	—
Thermal conductivity (CGS) 25° C. mean temp.	0.0100	0.0073		0.0037	0.0026	0.0062 to 0.0065	0.052
Linear coef. of thermal expansion $\times 10^7$ (25° to 300° C.)	14	57	−7	2 to 3	32	81.5 to 99 (20° C to 500° C)	95 (−18 to 316° C.)
MECHANICAL							
Modulus of elasticity (PSI $\times 10^{-6}$)	19.8	17.8			9.5	15	29
Poisson's Ratio	—	0.24			0.20	—	—
Tensile strength (PSI $\times 10^{-3}$) (For metals: ultimate strength)					—	13	80
Modulus of rupture (PSI $\times 10^{-3}$)	37	32			10	20	—
Strength to weight ratio M. R. strength/spec. gr. (PSI $\times 10^{-3}$)	14.1	12.3			4.48	6.85 to 7.56	10.1
Hardness:							
(1) Brinell 500 kg.	—	—			—	—	135-185
(2) Knoop 50 gm.	1100	940			550	—	—
500 gm.	720	570			—	—	147-201
(3) Abrasion (sand blast)—plate glass-1.0	27	20			3.10	—	—

Are You INTERESTED IN AGITATION In Laboratory-Scale High Pressure Reactions?

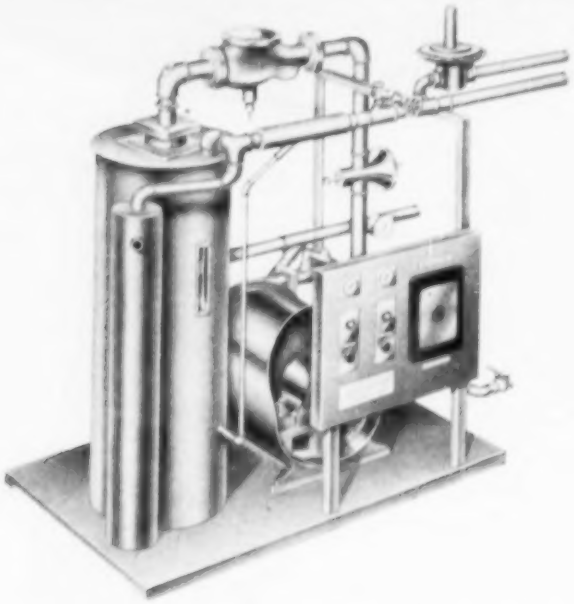
- Be sure to read this article in the April, 1957 issue of Industrial & Engineering Chemistry . . . or let us send you a reprint.



Autoclave Engineers

2933 WEST 22nd STREET • ERIE, PENNSYLVANIA

THE NEW SUB-X
INERT GAS GENERATOR
by THERMAL



A compact . . .

economical source of inert gases

THERMAL'S SUB-X generator offers unsurpassed operating economy and efficiency. Its unique design utilizes submerged exhaust of combustion products and permits the use of river water or other low-cost water supply as coolant.

The SUB-X generator is built around the THERMAL burner which can be fired with gas or distillate oil. Because of the burner's high heat release characteristics, the SUB-X generator eliminates refractory and reduces maintenance costs. Each unit is supplied as a complete package with all control and safety equipment. Standard models are available in capacities up to 35,000 SCFH of inert gas. Larger capacity units can be designed to your specifications.

WRITE FOR BULLETIN #114

OTHER THERMAL PRODUCTS & SERVICES
Gas, Oil, Combination Burners • Heat Exchangers • Submerged Combustion • Air Heaters • Combustion and Heat Transfer Engineering

IHEA

THERMAL
Thermal Research & Engineering Corp.
CONSHOHOCKEN • PENNSYLVANIA
REPRESENTATIVES IN PRINCIPAL CITIES

PYROCERAM

(*Continued from page 80*)

tion of more or less standard types of heat exchangers." Heat exchangers, according to Tomb, were chosen as one of the first production items because the firm has already had considerable experience in the fabrication of this type of equipment in various types of glass and is in a good position to switch over to Pyroceram exchangers on short notice. Since the new material can be handled with the same techniques as glass, few technical difficulties are anticipated.

Advantages over glass for heat exchange manufacture are obvious. Higher resistance to thermal shock will permit higher temperature gradients and hence better efficiency. Higher strength will make possible the fabrication of longer spans of pipe and will otherwise simplify mechanical handling. Such heat exchangers will also be able to carry more abrasive slurries than present glass exchangers.

Stacked up against steel for this use, Pyroceram would at first glance seem to be somewhat handicapped because of its lower thermal conductivity. However, it is claimed that at higher temperatures its emissivity factor for radiant heat is more favorable than that of steel. This fact, combined with much lower cost, may well make Pyroceram a strong contender for this market.

Other suggested uses in the manufacturing and processing field include: pump impellers and gas turbine blades, tower packings such as Raschig rings, etc., friction uses such as brake linings, and electrically-conducting films for radiant heating.

The Process

At the start, certain nucleating agents are added to batches of special glasses. The batch is melted, formed, and cooled as in ordinary glass manufacture. Key to the new process lies in the subsequent controlled heat treatment during which the nucleating agent furnishes "seed" crystals for the formation of a fine-grained crystalline material totally unlike the amorphous glass from which it came. According to Dr. S. Donald Stookey, inventor of the process and manager of Corning's Fundamental Chemical Research Department, nuclei size is believed to range down to about ten atoms in diameter; in any case, they are under 300 Å. The ultimate size of the mature crystals in the Pyroceram materials runs from 1 to 2 microns down. This is to be compared with a size

range of 20 microns up in most ceramics.

Many different nucleating agents have been employed with success, the choice depending on the properties desired in the final product. More than 1,000 types of Pyroceram have been melted experimentally. Of these, however, only four have been investigated on a pilot plant scale. This fact in itself should give some indication of the work which remains to be done.

The Product

The new materials seem to contain crystals of a structure not found either in nature or in other man-made substances. They differ from ordinary ceramics in that the grain structure is much finer. While the actual crystal structure is said to be that of a polycrystalline oxide, Stookey emphasizes that the pattern is not uniform but varies with the type of Pyroceram. Variations in the process can produce opaque, translucent, or clear types of Pyroceram materials at will.

Pyroceram 8605 is said to have a tensile strength of 37,000 lb./sq.in. and very little loss of strength at temperatures up to about 1,400° F. Stookey, however, hopes to attain tensile strengths up to 80,000 lb./sq.in. in the future. This would put the material on a par with most of the stainless steels in this respect. The temperature limit is also being pushed higher and higher in experimental work. Immediate goal is from 2,800 to 3,000° F. Retention of strength at elevated temperatures is due in part to the fact that oxidizing atmospheres do not affect the material to any significant degree.

Harder Than Steel

Tests have shown that certain types of Pyroceram are harder than flint, granite, or hardened high carbon steel, but not as hard as sapphire. Specific gravity of most types is less than that of aluminum. It is non-porous and almost completely impermeable to moisture or gases.

Thermal expansion in the Pyroceram materials can range from slightly negative to 200×10^{-7}/° C. This compares to 95×10^{-7}/° C. for stainless steel. Certain kinds of Pyroceram have about four times the thermal conductivity of borosilicate glasses. However, their thermal conductivity is less than that of stainless steel, for example, by a factor of about five. Thermal shock properties are said to be excellent. For example, Pyroceram has a thermal shock resistance greater than that of dense aluminum, and equiva-

(Continued on page 84)



1500 gal. reaction kettle used in manufacture of phenol formaldehyde resins by Booty Resineers, Inc. A BS&B Safety Head protects this equipment which has a normal operating pressure of 12 psi @ 200° F.

Booty Resineers, Inc. of Newark, Ohio, manufactures phenol formaldehyde resins used for the bonding of many industrial products. BS&B Safety Heads equipped with vacuum supports provide the necessary protection against overpressure conditions in five of their reactor kettles.

BS&B Safety Heads are in service in hundreds of diverse industries throughout the world, providing safety protection to pressured systems. Some of these applications require special coatings for the Rupture Disc to combat corrosive conditions. Many call for special materials and construction to withstand extreme operating temperatures and/or pulsating pressures.



THE "CIRCUIT-BREAKER" OF Pressured Systems

In every case where the BS&B Safety Head Unit is matched to the specific operating conditions, performance has proven quite satisfactory. If you would like some assistance in determining the best type of BS&B Safety Head and Rupture Disc for your particular pressured system, contact your nearest BS&B Representative or write to . . .

BS&B — ANOTHER EXAMPLE OF PRODUCT LEADERSHIP

BLACK, SIVALLS & BRYSON, INC.

Safety Head Division, Dept. 2-DX7
7500 East 12th Street
Kansas City 26, Missouri

DOYLE & ROTH
"DEPENDABLE"
HEAT TRANSFER
EQUIPMENT



FOR GREATER ECONOMY
and
DIVERSIFIED APPLICATION

In the *modern and up-to-date* Doyle & Roth plants, we have *every means* of designing, developing and fabricating precision tubular products.

Our engineering department has met many *unusual problems* requiring extensive knowledge in the field of heat transfer engineering. *This "know-how" is available to you.*

D. & R. also passes on to you, the economies of its *standardization program.* Starting with engineering and following through on construction, *economies are substantial.*

Materials are purchased to *rigid specifications* and *standard components are stocked.*





CONTACT DOYLE & ROTH
For prompt attention to your
INDIVIDUAL REQUIREMENTS

DOYLE & ROTH
Manufacturing CO. INC
136-50 TWENTY-FOURTH STREET, BROOKLYN 32, N. Y.

PYROCERAM

(*Continued from page 83*)

lent to that of fused silica. Table 1 exhibits typical thermal and mechanical properties of some types of Pyroceram compared with glass, ceramic, and metal.

Time has been too short as yet to carry out long-term corrosion tests. Preliminary indications are that Pyroceram *8607* and *8608* are nearly as resistant to acid attack as certain of the Pyrex brand borosilicate glasses and even more resistant to alkali attack. Quantitative data obtained to date are shown in Table 2.

Stookey makes it clear that he considers much more research necessary before the whole potential of this family of materials becomes evident (it is a *family* and not a single new material which has been discovered). For instance, while experimental work is just in early stages, it is believed that certain of the Pyroceram materials, like some metals, exhibit definite solid state phase changes at critical temperatures. This factor will undoubtedly have a bearing on their use for certain applications.

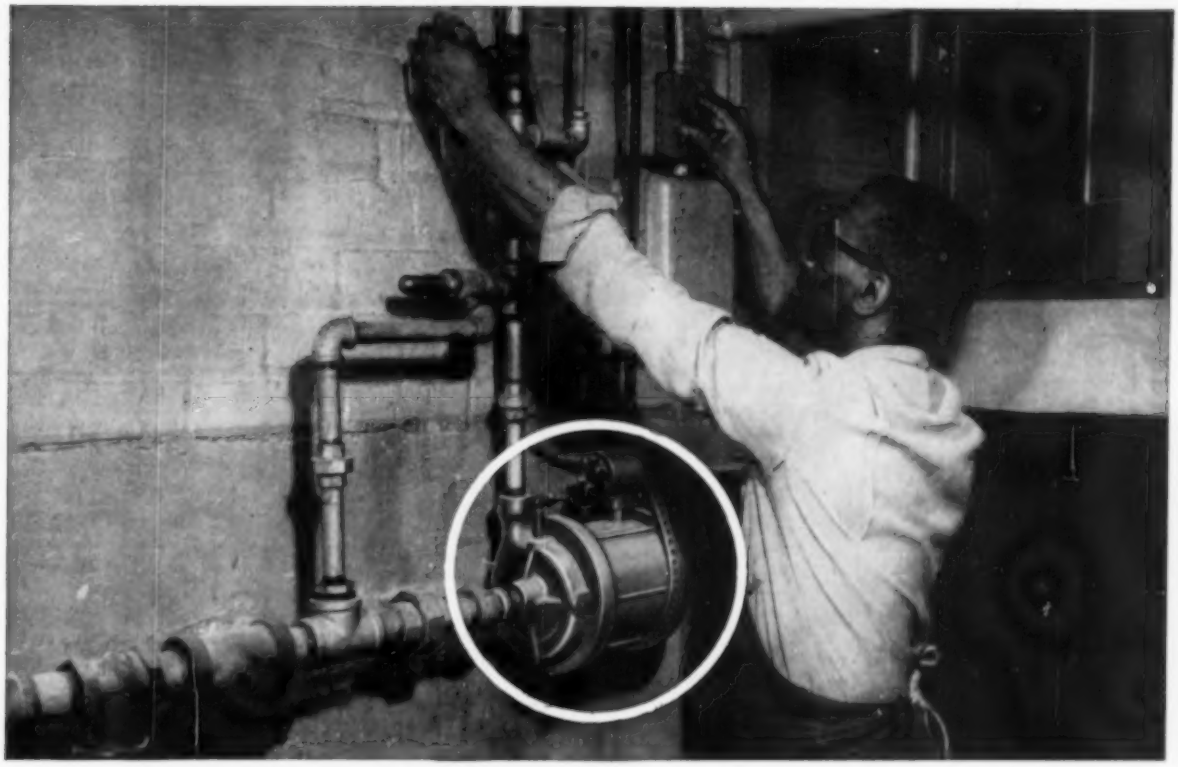
The entire low temperature region remains unexplored. When completed, investigations in this range are likely to predict important uses in low temperature chemical processing equipment. For the engineer interested in solid state physics, the behavior of these materials at temperatures approaching absolute zero will be of importance. Will they obey the heat capacity law for perfectly crystalline substances, will they act as glasses, or will their behavior be such as to require entirely new theoretical considerations?

"In general," says Stookey, "types of Pyroceram tested to date have indicated that high tensile strength is associated with somewhat lower corrosion resistance and vice versa. More research will be necessary to combine optimum properties for specific industrial uses."

Nuclear Uses?

In answer to questioning on the future of Pyroceram materials in the nuclear field, Stookey confirmed that a small number of actual in-pile tests have been run to determine the effect of nuclear radiations on the materials. In the samples tested, no change in mechanical or electrical properties was detected. Further work may well open up a whole field of nuclear processing applications, including perhaps the fabrication of fuel elements. Another application could be the handling

(*Continued on page 86*)



Chempump holds costs down

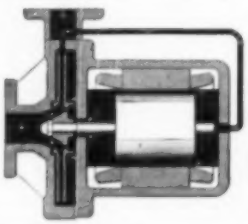
handling trichlorethylene at Argus Cameras

The explosion-proof *Chempump* shown above is one of two used at the Argus Cameras Division of Sylvania Electric Products, Inc., plant in Ann Arbor, Mich. to move trichlorethylene from storage to holding tanks.

Trichlorethylene—expensive and highly volatile—is used here at Argus for degreasing. It's hard to hold—seeps through conventional pump packing and dissolves packing lubricants. Leakage could mean continual maintenance expense, loss of costly trichlorethylene, and the hazard of explosion.

For Argus, *Chempump* eliminates these problems because it can't possibly leak—has no seals, no stuffing box, no packing. Simplicity of design reduces maintenance to an occasional inspection and replacement of bearings. External lubrication is never required . . . bearings are constantly lubricated by the pumped fluid itself.

You have much to gain through leakproof fluid handling with Chempump in your own processing operations. For details, write to Chempump Corporation, 1300 East Mermaid Lane, Philadelphia 18, Pa. Engineering representatives in over 30 principal cities in the United States and Canada.



Chempump combines pump and motor in a single, leakproof unit. No shaft sealing device required.

U.L. approved. Available in a wide choice of materials and head-capacity ranges for handling fluids at temperatures to 1000 F. and pressures to 5000 psi.

Chempump

First in the field...process proved



Falls Industries is first again...

with Comprehensive Data for Cost Estimation of Impervious Graphite Processing Equipment

This 32 page report presents costs and equipment specifications on all the standard impervious graphite processing equipment produced by Falls Industries. Equipment is illustrated with drawings, diagrams or photographs. Costs are tabulated in dollars per square foot of heat transfer surface, or other convenient unit.

Also covered in this report are the famous IMPERVITE impervious graphite Rupture Disk, and the IMPERVITE CROSSBORE heat exchanger—the most recent exclusive developments of Falls Industries.

The following unsolicited comments are typical of the many received:

"This is exactly the type of information we like to get with costs included."

"It presents the most comprehensive picture of equipment data issued on the subject."

Follow the responsible leadership of Falls Industries for practical development of better processing equipment, and greater service.

FALLS FI INDUSTRIES INC.
PHONE: CHurchill 8-5357
TELETYPE: SOLON 0-720

FALLS INDUSTRIES, INC.
31911 Aurora Road • Solon, Ohio
Gentlemen: Send me a copy of your "DATA FOR COST ESTIMATION" Bulletin No. 249.
Name ..... Title .....
Company .....
Address .....
City ..... Zone ..... State .....

PYROCERAM

(Continued from page 84)

of liquid metal coolants in reactor technology. While no actual tests have been undertaken as yet, this application is understood to rate a high priority on Corning's research schedule.

Economics Seem Favorable

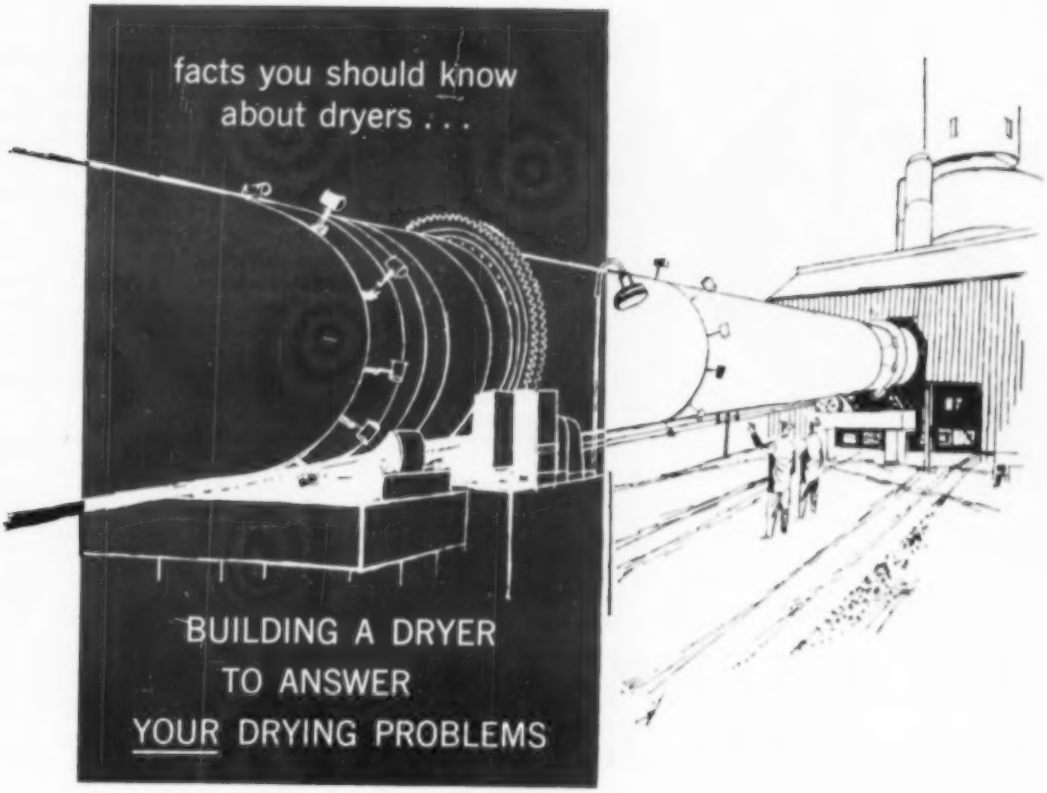
Corning estimates that Pyroceram will probably cost "little more than glass and far less than stainless steel." This estimate is based on the fact that the material can be handled by the conventional mass production techniques used in glass manufacture—blowing, pressing, drawing, or spinning. In addition, certain of the Pyroceram materials, which are very fluid in their glassy state, can be handled by such special forming techniques as centrifugal and investment casting. This feature promises to make possible the economical manufacture of even the most complex forms and shapes. While Pyroceram can not ordinarily be machined, the fabricated equipment can be ground to finished dimensions in the glass state, then "ceramed." Practically no shrinkage is said to occur when the material takes its crystalline form.

Welding Technique

Techniques are now being worked out for field welding of Pyroceram piping and equipment, says George W. McLellan, staff engineer in Corning's Research and Development Division. These methods will probably involve melting the ends of the pieces to be joined. However, difficulties are introduced by the effect of heat on the crystal structure, that is, by the transition between the glassy and crystalline forms of the material. Possibility of welding depends on the individual type of Pyroceram. McLellan says that, while satisfactory methods will doubtless be evolved, they will probably demand more complicated procedures than are presently used in the case of glass equipment.

Sub-Licenses?

"Research accent is still on determination of the properties of the material," insists McLellan, "rather than on mass production of equipment. However, Corning anticipates heavy demand for Pyroceram in various forms, and is prepared to expand production facilities to meet it." This would seem to indicate that Corning is planning to run the whole show, at least for the foreseeable future.



For over 55 years, Louisville Dryers have been solving industry's drying problems and effecting marked economies. The following is intended as an introduction to selecting the right type of dryer.

Q. *Since my required production capacity indicates a continuous dryer will give lowest drying cost, which design is best for my purpose?*

A. Assuming the material is in bulk form, a rotary type dryer is best for your purpose. It is almost axiomatic that materials suited to drying in rotary dryers are dried at lowest *overall* cost in that type.

Q. *If I consider a rotary dryer, should it use high temperature furnace gases or low temperature warm air to dry my material?*

A. This will depend on your particular material, for instance—

1. The temperature to which it can be heated without injury.
2. The amount of moisture in the wet material.
3. The material temperature necessary to dry the material to the desired final moisture content.
4. Whether or not the material will be contaminated by contact with combustion gases.

Q. *I think my material will not be injured by gases from an oil furnace. Should I use a parallel or counter current rotary dryer?*

A. This will depend on a number of considerations, such as:—

1. Is the material flammable?
2. How dry must the product be?
3. Is the dried product dusty or is it granular with very small percentage of "fines?"
4. Will "case hardening" occur in high temperature atmosphere inhibiting uniform and complete drying of large lumps and particles?

Q. *There seems to be quite a number of conditions affecting the selection of the proper dryer type.*

A. Very true. And the conditions involved are not all included in the above discussion by any means.

Q. *How can I be sure of making the proper choice?*

A. An experienced drying engineer knows how to evaluate the various conditions involved in each drying problem and will make a sensible recommendation. If advisable he will also recommend pilot plant tests to confirm his conclusions.

Q. *How can I obtain such advice?*

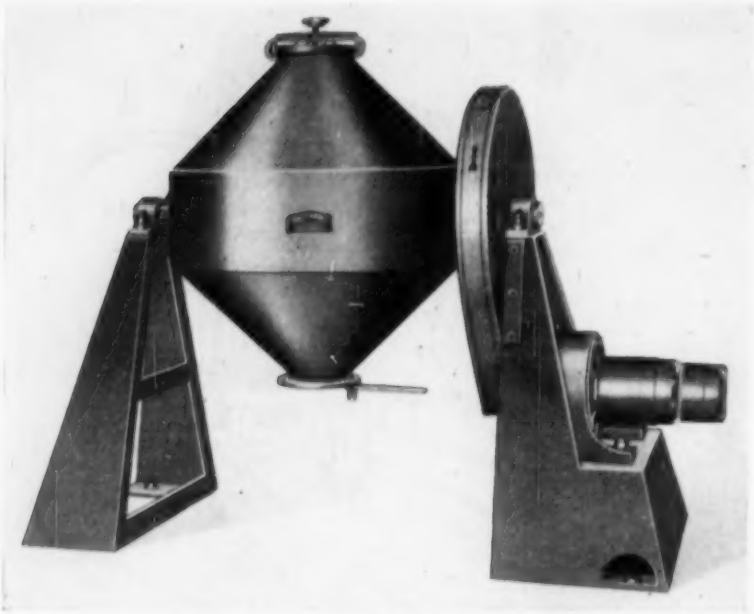
A. Submit your problem to General American. An analysis and recommendation by a LOUISVILLE engineer entails no obligation on your part.

PROCESS EQUIPMENT DIVISION
GENERAL AMERICAN
TRADE MARK

LOUISVILLE DRYING MACHINERY UNIT

GENERAL AMERICAN TRANSPORTATION CORPORATION

Dryer General Sales Office: 139 So. Fourth Street, Louisville 2, Kentucky
Eastern Sales Office: 380 Madison Avenue, New York 17, New York
In Canada: Canadian Locomotive Company, Ltd., Kingston, Ontario, Canada
General Offices: 135 S. La Salle Street, Chicago 90, Illinois



Cut DRY BLENDING *Costs* with the PAUL O. ABBÉ ROTA-CONE BLENDER

Widely acknowledged throughout the process industries as the fastest and most thorough method or dry blending, the Paul O. Abbé Rota-Cone Blender cuts costs in several ways.

Modest initial equipment cost.
Extremely low maintenance costs.
Long useful machine life.

LOW ANNUAL EQUIPMENT COSTS

Fast blending cycle means high production rate.
Easily cleaned for product change-over.
No skilled labor needed.
Low power requirements.

LOW OPERATING COSTS

LOW ANNUAL EQUIPMENT COSTS + LOW OPERATING COSTS EQUALS LOW PROCESS COST.

Made in a complete range of sizes from 9" to 120" in diameter with operating capacities from 1 to 2440 gallons

For complete details write for descriptive folder.

PAUL O. ABBÉ

BALL AND PEBBLE MILLS, DRY AND PASTE MIXERS, JAR MILLS, ROTA-CONE BLENDERS & DRYERS

271 Center Avenue **Little Falls, New Jersey**

NUCLEAR NEWS

An Atomic Energy Course for Management will be held at the Hotel Moraine on the Lake, Highland Park, Ill., Oct. 6-12, 1957, under the auspices of the National Industrial Conference Board. Purpose is to acquaint non-scientifically trained business executives with the basic facts of atomic energy, its industrial applications, and its effects on our economy and business practices. Registration forms available from National Industrial Conference Board, 460 Park Ave., New York 22, N. Y. □

Several sites are under consideration by Olin Mathieson Chemical for the construction of a small nuclear reactor core assembly plant. Latest site, with an option taken, is near Montville, Conn. Olin already has a pilot plant in operation in New Haven, Conn., expects to eventually build a large plant on whatever site it selects. □

Industry is saving nearly $400 million annually through the use of radioisotopes, an AEC official has said. This amount can be expected to increase "several fold" over the next five to ten years, E. E. Fowler, deputy director of the AEC Division of Civilian Applications explained. But there is a long way to go in securing a really significant use of radioisotope techniques. Fowler believes that peaceful uses of nuclear materials are being held back, "because we (AEC) have not been overly successful to date in bringing to bear directly on management the vast amount of information and technology currently available on non-power uses of nuclear materials." □



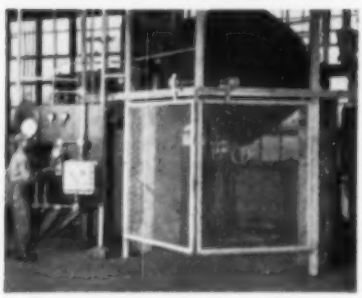
Workmen apply Foamglas block insulation to one of the giant acid thickener tanks at Rio Tinto Mining Company's uranium processing facilities at Algom-Quirke in the Blind River area of Canada. Since all ore processed must pass through these tanks, and since they are much too large to build indoors, it was essential that they be insulated to prevent the leaching solution from freezing in the sub-zero weather of Canada. Foamglas, supplied by Pittsburgh Corning Corp., did the trick

Corrosioneering News

Quick facts about the services and equipment available to help you reduce corrosion and processing costs.

Published by The Pfaudler Co., Rochester, N.Y., U.S.A.

Toms River-Cincinnati Chemical reduces dyestuff drying time by 90%



The Pfaudler conical dryer-blender eliminates losses from finely divided material flying off in the air. No manual handling of the contents is required.

A particular problem at the Cincinnati plant of the Toms River-Cincinnati Chemical is drying dyestuff intermediates that are sensitive to air absorption at elevated temperatures.

Drying time has been reduced from 36 hours, required for chamber drying, to 4 hours using a Pfaudler glassed steel conical dryer-blender. In the tumbling action of the Pfaudler conical dryer-blender, the drying is simultaneous throughout the charge, drastically cutting 90% off the time required for each batch. In addition, a better product is obtained because the material is exposed to elevated temperatures for a much shorter period.

Labor costs per pound of material handled have been reduced by 50%. The material to be dried is introduced directly into the drying chamber of the Pfaudler conical dryer-blender.

The corrosion and contamination problem associated with chamber drying is completely eliminated with the Pfaudler conical dryer-blender. The material is poured directly into the glassed steel drying chamber which protects the contents against contamination and prevents corrosion of the equipment.

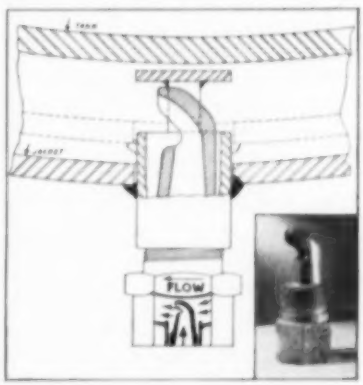
Because the dyestuff intermediates have a very fine consistency, unloading from the pans is a very dusty operation, and is accompanied with appreciable losses.

With the Pfaudler conical dryer-blender, the material is removed from the bottom. The neck of the receiving container is neck to neck with the discharge opening.

You can use Pfaudler glassed steel conical dryer-blenders for every kind of acid except hydrofluoric and hot concentrated phosphoric — for alkalies up to pH 12 at 212° F.

Sizes range to 165 cu. ft. working capacity and are available in four different diameters: 2 ft., 4 ft., 6 ft., and 8 ft. You can test your product in our laboratory or in your plant with a Pfaudler loan unit. Send for Data Sheet 26. It will give you all the details.

New data on turbulent flow in reactor jackets



Capacities and characteristics of the Pfaudler Agitating Nozzle and its superiority over the commonly used spiral jacket are discussed in a new bulletin No. 950. Working basis for the agitating nozzle is the use of kinetic energy. This is available through the pressure and volume of the heating or cooling liquid delivered to the reactor as a direct means of producing circulatory movement of entire contents of jacket. Capacity chart and typical hookup of nozzles are shown. Method of selecting nozzles is fully covered. Ask for Bulletin No. 950.

Custom-built copper and copper alloy process equipment



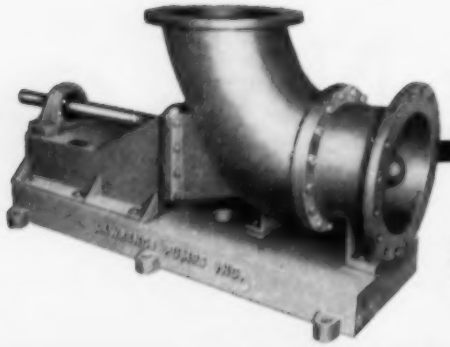
Pfaudler can fabricate copper or copper alloy vessels to your process requirements.

If your process involves acid solutions of low oxidizing capacity, copper or copper alloys may be one answer to your equipment construction problem.

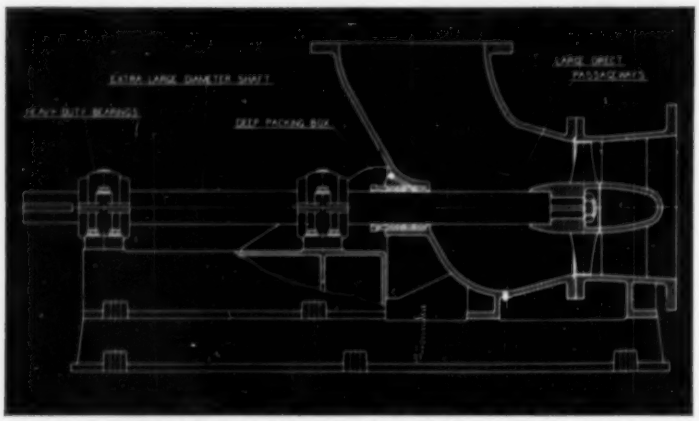
As corrosion specialists, Pfaudler fabricates numerous metals and alloys, including copper and copper alloy vessels and tanks. With many years experience in brewery equipment manufacture, where copper is widely used, Pfaudler coppersmiths are second to none. Their craftsmanship is attested to by the long-term performance record of their wares.

For large or small equipment, Pfaudler copper manufacturing facilities are complete and economical. If you require heat treating, our furnace capacities will handle vessels up to 13 feet in diameter by 45 feet in length.

Discuss your next custom copper fabrication with Pfaudler too.



Lawrence 24" Horizontal Circulating Pump of Nickel Alloy Construction



Cross Section of Lawrence Horizontal Propeller Pump

PROPELLER PUMPS
FOR THE
CHEMICAL and PROCESS INDUSTRIES

Lawrence Propeller or Axial Flow Pumps are widely used to circulate large volumes of liquid or slurry against low heads as in evaporators, crystallizers, etc. This type of pump is particularly well adapted for circulating service because of its simplicity, high efficiency, and low first cost. The flow can be arranged in either direction and the casing turned to any position desired to serve as an elbow. The capacity can be closely regulated by varying the speed—very important in crystallization processes where a uniform velocity must be maintained.

Lawrence Propeller Pumps are made of the metals and alloys best suited for their ability to resist the corrosive and abrasive action of the liquid pumped.

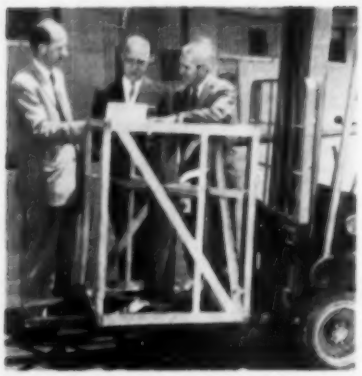


Write for Bulletin 203-7 for summary of acid and chemical pump data.

LAWRENCE PUMPS INC.

371 MARKET STREET, LAWRENCE, MASS.

NUCLEAR NEWS



In the crate is a shipment of enriched uranium fuel material (uranyl sulfate enriched to approximately 20% in U-235) destined for use in the under-construction research reactor in Denmark. Accepting the shipment in an informal ceremony at Idlewild Airport in New York is Erik Thrane (left) Danish Economic Counselor. On the right is S. K. Braiden, chief of Nuclear Materials Branch, Technical Liaison Division, AEC, and in the center is Louis Horton of the Special Metals Division of Mallinckrodt Chemical Works who manufactured the material.

A contract to perform consulting services on the Pennsylvania Advanced Reactor Project has been awarded to Walter Kidde Nuclear Laboratories. The Project itself is a major development effort leading to the design of an aqueous homogeneous reactor plant having an electrical output of 150,000 kw. Sponsors of the project are Penn. Power & Light and Westinghouse Electric. □

Shippingport Atomic Power Station is expected to start producing usable power late this year. Preliminary operation of what is America's first full-size atomic plant "is proceeding satisfactorily and is expected to continue in the same manner." The reactor station, located near Pittsburgh, has encountered no problems greater than those of a conventional power station. □

Only Eastern uranium mill, Ramapo Uranium Corp.'s Warwick, New York, installation, is now operating under the terms of a one-year contract with AEC. The Commission has agreed to purchase, at $8 a pound, U_3O_8 in uranium concentrates to a maximum of 50,000 pounds of U_3O_8. The mill, a pilot plant scale unit, will process uranium bearing ores of the Warwick area. Main purpose of the plant—to determine the feasibility of producing uranium concentrates from such ores on an economical basis using a gravity separation process. □



WHEN you consider expansion...

...the most important investment you can make is in the creative ability of men.

FLUOR

The Fluor Corporation, Ltd.

Engineers & Constructors

2500 S. Atlantic Blvd., Los Angeles



Spraco full-cone, free-flow nozzle discharging 860 gpm at 5 psi. This photo was taken at 1/5000 sec. shutter speed . . . at this speed the pulsations of the pump are apparent in the spray pattern.

RADICALLY NEW!

full-cone FREE-FLOW *nozzles from* SPRACO



Spraco's totally new, full-cone free-flow nozzles have been specially developed for high capacity, low pressure installations where clogging is a problem and full-cone spray pattern a necessity. Streamlined internal vane construction, with maximum vane openings, offers minimal flow resistance, virtually eliminates clogging.

STANDARD MATERIALS — bronze, cast iron, or stainless steel. Or, to order from any cast machineable material.

SPRAY CHARACTERISTICS — uniformly distributed full cone spray.

PIPE CONNECTION — 4"–8".

CONNECTIONS — screwed or flanged.

APPLICATIONS — cooling towers, chemical processing, coke quenching, aerating and purifying water supplies, cooling ponds, packed towers, absorption towers, etc.

Spraco welcomes your spray nozzle problems. As a leading consultant to industry for over 42 years, we are at the forefront in special nozzle development.

Write today for free, 30-page nozzle catalog. A complete selection of standard nozzles are available from stock.

SPRACO NOZZLES



SPRAY ENGINEERING COMPANY

132 Central Street, Somerville 45, Mass.

NUCLEAR NEWS

Plans to devote a much greater effort to the development of economic methods for producing heat for industrial use from nuclear reactions are in the work in England by the U.K. Atomic Energy Authority. Work on special reactor types for this purpose is underway, prime consumers would be the chemical and steel industries. Scientists at both Harwell and the Industrial Group at Risley are optimistic, think this aspect of nuclear energy can become as important as the generation of electricity. □

A formal contract for an 11,500 kw atomic power plant has been signed between Westinghouse Electric International Company and Societe Cooperative Electro Nucleaire of Belgium. The reactor will furnish electrical energy to Belgium by the end of 1959. The Westinghouse unit will embody the latest advances in pressurized water reactor design and will utilize slightly enriched uranium oxide as fuel. □

A contract to make nuclear fuel elements for a tank-type research reactor has been signed between Babcock & Wilcox and the Danish Atomic Energy Commission. The contract calls for 45 fuel element assemblies, including 33 standard units and 12 with provisions for controls. They will be fabricated from uranium enriched to 20% of the U-235 isotope. Delivery of the completed fuel element assemblies is scheduled for September 1. □

The 2nd Winter Meeting of the American Nuclear Society will be held at the Henry Hudson Hotel in New York from October 28 to 31. □



A technician arranges plastic tensile specimens at the new Western Service Irradiation Center of Applied Radiation Corp. where industrial and academic organizations can use one of Applied Radiation's linear electron accelerators on a rental basis. Research in radiation chemistry, radiation preservation of foods and drugs, and solid state physics is already underway.

News from
National Carbon Company
Division of Union Carbide Corporation · 30 East 42nd Street, New York 17, N. Y.
Sales Offices: Atlanta, Chicago, Dallas, Kansas City, Los Angeles, New York, Pittsburgh, San Francisco. IN CANADA: Union Carbide Canada Limited, Toronto

PROCESS EQUIPMENT BRIEFS

New Data Sheets Give Product Specifications on "Columbia" Brand Activated Carbon

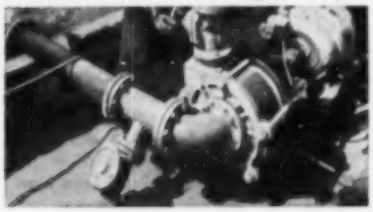
Designed to facilitate selection of proper type and grade of "Columbia" Activated Carbon in gas purification, gas separation, air conditioning, and catalyst applications. Includes product description, typical applications, properties, screen analyses and pressure drop curves. Request supplement to **Catalog Section S-6450.**

Technical Information on "National" Carbon Brick Now Includes Corrosion Resistance Tables



Cover use of "National" Carbon Brick for lining tanks, reactors and similar process vessels containing corrosive liquids or gases. Photograph above shows "National" Carbon Brick linings and "Karbate" Plate Type Heat Exchangers in nitric-hydrofluoric acid stainless steel pickling tanks.
Catalog Section S-6215

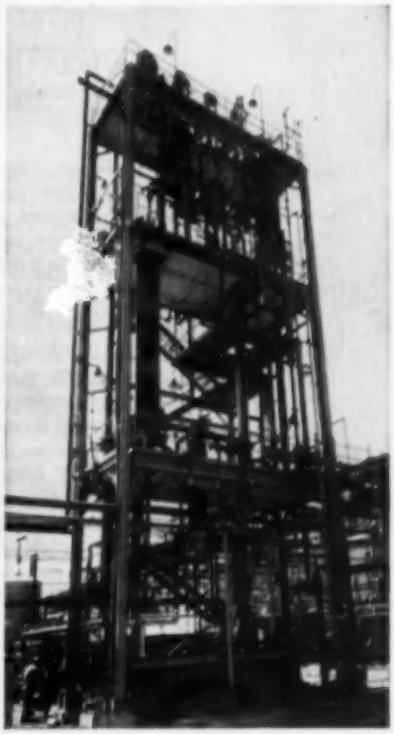
HCl Storage—Loading Facilities Use "Karbate" Centrifugal Pumps



"Karbate" Centrifugal Pumps load and unload commercial strengths of hydrochloric acid at tank farms. Pump capacities up to 1500 gallons per minute at heads up to 125 feet cover wide range of loading requirements.
Catalog Section S-7250

"KARBATE" Impervious Graphite Vital to Increasing HCl Production

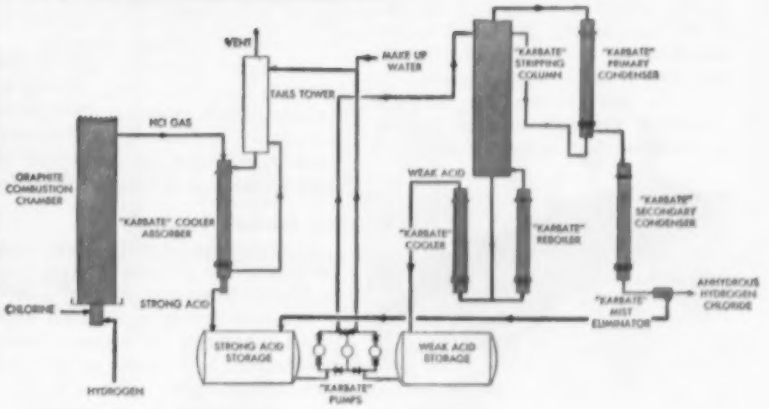
Major Plant Items: **"KARBATE" Falling-Film Absorbers, Stripping Towers, Boilers, Coolers, Condensers, Pumps and Piping.**



Process improvements made possible by National Carbon's introduction of impervious graphite have established hydrochloric acid and anhydrous hydrogen chloride as major industrial chemicals. Today, "Karbate" impervious graphite equipment is used in all HCl production processes.

Photograph at left shows typical plant equipment producing anhydrous hydrogen chloride from by-product HCl. Flow sheet below emphasizes the role of "Karbate" impervious graphite in this operation; the "National" Graphite Combustion Chamber shown is frequently used to produce raw HCl gas by combustion of hydrogen and chlorine.

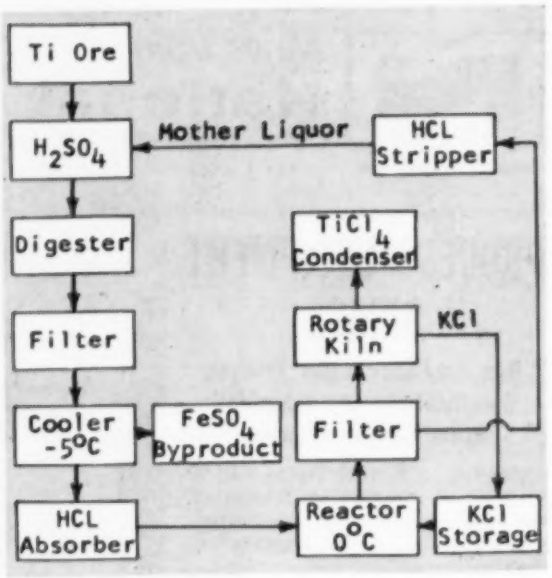
The durable construction of "Karbate" shell and tube heat exchangers, towers and centrifugal pumps is important to the design and continued economy of all types of HCl processes. A wide range of items available from stock at moderate cost. For details on "Karbate" equipment in HCl production, request **Catalog Section S-7460 NL.**



NATIONAL TRADE MARK

The terms "Karbate", "Columbia", "National" and the "N" and Shield Device are trade-marks of Union Carbide Corporation

Flow sheet for titanium tetrachloride from cold chlorinated titanium solutions.



NEW PROCESS FOR TITANIUM

Armour's new process for production of titanium tetrachloride from low-grade ore or scrap at low temperature could have wide importance in increasing the utilization of the high-potential metal in process industries.

Big stumbling block in titanium utilization—price of fabricated products—is being attacked from both ends. Present cheapest kind of mill product is about $6.00 a pound (average price $9-10 a pound) after recent wide price reduction of some 10 per cent. The industry is continually working on improvements in fabrication.

Now Armour Research Foundation (Illinois Inst. of Technology) has come up with a new process on the other end—to produce titanium tetrachloride from low-grade ores at low temperature. Advantages claimed are:

- Use of low-grade ore, such as ilmenite, or any titanium-containing materials such as scrap or slag.
- Use of hydrogen chloride instead of chlorine for the chlorination.
- Low operating temperatures in the chlorination and decomposition stages.
- Higher purity tetrachloride due to the selective chlorination which excludes coprecipitation of other impurities.

The Process

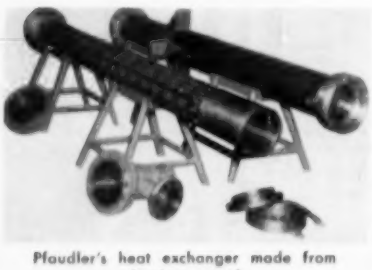
According to F. Schossberger, Armour Research, the main process in use today, the high temperature chlorination of rutile (a high-titanium ore in much shorter supply than ilmenite and other low titanium ores), is too expensive when used on low-grade ores, largely through the consumption of excess chlorine in the chlorides of other metals present.

In the new process, the titanium-containing material, such as ilmenite or titanium slag, is treated first with sulfuric acid in much the same way as done in the titanium dioxide pigment industry. If iron is present in appreciable amounts, it must be separated from the system by crystallizing ferrous sulfates at a temperature below that of the subsequent alkali chlorotitanate precipitation.

After separation of the iron sulfates, if any, the solution is cooled to about 0° C. and saturated with hydrogen chloride. Solid potassium chloride is added to this solution and potassium chlorotitanate is precipitated. This compound, in which titanium is present in the form of the complex anion $[TiCl_6]^{-2}$, is stable and is soluble in water without hydrolysis.

The yellow complex salt is separated and decomposed easily by being heated to 300-500° C. to yield titanium tetrachloride in a condenser, with potassium choride as a residue. The potassium chloride is then recycled into the process, together with the mother liquor, after stripping the latter of excess hydrogen chloride.

The higher purity of the titanium tetrachloride made in this way is, according to Schossberger, the result of the selective crystallization of the solid titanium salt and its subsequent decomposition into a volatile compound.



Pfaudler's heat exchanger made from titanium metal.

The Economic Potential

At present in the early stages of development, the Armour process could be highly important to the industry if it works out in commercial application. ARF is at present ironing out the details, is ready to go ahead with demonstration pilot unit, would welcome industry participation.

J. H. Garrett, chairman of the Dept. of Defense Steering Group on Titanium Research and Development, estimates that the present approximate price of sponge ($2.75 to $2.25 a pound) should be reduced to no more than $1.00 a pound, and that in the long run ilmenite must be the ultimate raw material unless a great deal more rutile is found.

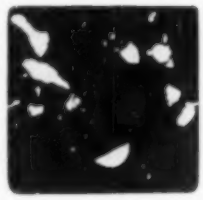
The principal advantage of the Armour process is clear. It uses ilmenite, which, while it has only 40% as much titanium dioxide content as rutile, is far more abundant and yields titanium at a lower unit cost.

At the same time, separation of iron in the form of sulfates from ilmenite that has been digested in sulfuric acid—a procedure familiar to the pigment industry—is the key to the reduction of chlorination costs.

An additional advantage in the cold chlorination process seems to be the use of hydrogen chloride instead of chlorine, and by replacing the high temperatures necessary with chlorine Armour feels that substantial savings can be realized in the cost of equipment.

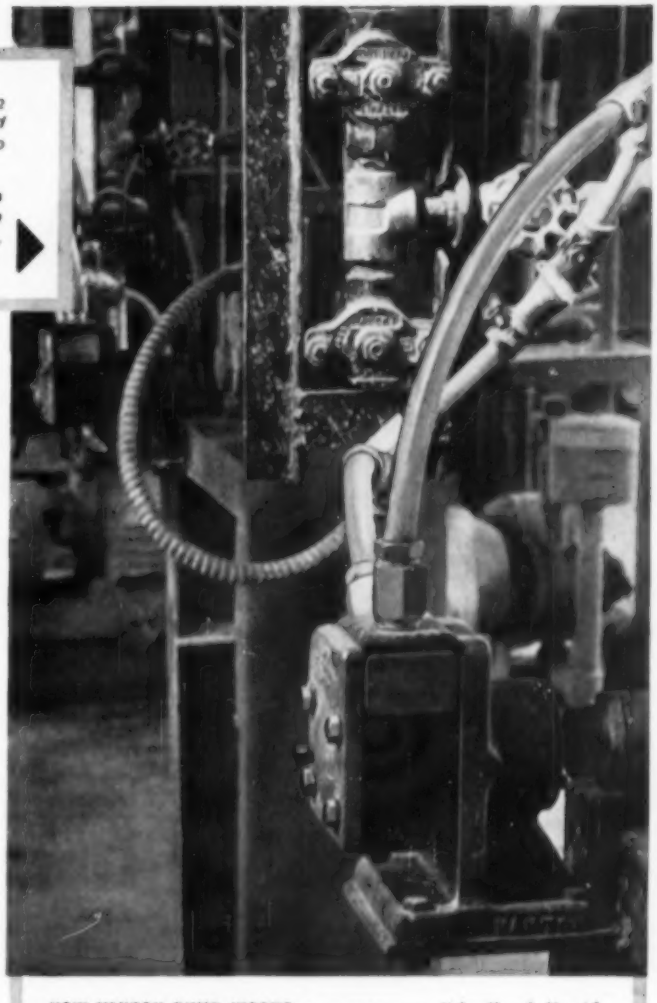
TITANIUM PRICE REDUCTION

The recent price reduction on finished titanium mill products was expected, was not, according to the Government, caused by the recent "stretching out" of production of the B-52 which uses a considerable amount of titanium. In fact, the price drop should have been more if the needs for titanium had increased as expected. Since the demand has not built up as much as estimated, there is a slight overcapacity in titanium at the moment, but the level of production is still high, the slack is expected to be taken up very soon.



Highly abrasive: *ZrO_2 grains, X2150, are passed through the pump with no harm to internal parts.*

Vanton Sealless Pumps *Move 30% ZrO_2 Slurry From Settling Cones To Filters. Temperature 80-135°F.*



VANTON PLASTIC PUMPS (No Stuffing Box or Shaft Seals) Handle Acidic Abrasive 30% ZrO_2 Slurry With No Leakage

At Zirconium Corp. of America's Solon, Ohio Plant

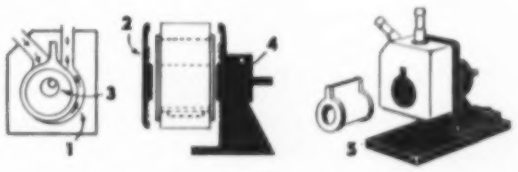
Pumping zirconium oxide (ZrO_2) slurry is no easy job. At Zircoa's plant, where stabilized ZrO_2 is manufactured in a patented continuous-flow process, slurry must be pumped continuously. Before Vanton came on the job, these abrasive, acid slurries caused periodic breakdown of conventional pumps, eroding impellers, scoring shafts, causing packing leakage and corrosion.

When Zircoa shifted to Vanton sealless plastic pumps, which have no shaft seals or packing glands (see diagrams) these troubles ceased. The Vanton plastic body block and synthetic rubber flex-i-liner proved completely impervious to the acid slurry. The resilient flex-i-liner absorbs the abrasive effect of the slurry with minimal wear. With corrosion and abrasion eliminated, maintenance was reduced to the simple, infrequent replacement of the inexpensive flex-i-liner.

Whether your problem is corrosion, abrasion, or contamination, you will find a Vanton flex-i-liner pump right for the job. *Why not send for the complete story today?*

CHECK THESE VANTON SEALLESS PUMP ADVANTAGES! ● ***No stuffing box or mechanical seal to leak, contaminate, or require maintenance*** ● ***Self priming; high vacuum*** ● ***A full-time production tool*** ● ***Broad capacity range, ½-40 GPM*** ● ***Available in 7 body and 10 flex-i-liner materials, to handle a wide variety of corrosives and abrasives.***

HOW VANTON PUMP WORKS • Liquid flows in channel between molded plastic body and synthetic flex-i-liner (*1*). No liquid touches metal. Liner flanges secured to plastic body block by bolted face plates (*2*). • Pumping mechanism is rotor mounted on eccentric shaft (*3*). At each revolution it pushes liner against body block and sweeps a "slug" of liquid around the circular track from inlet to outlet. • All bearings are outside of fluid area and located within protective stainless steel assembly in the event of flex-i-liner failure (*4*). • Liners are replaced in minutes, with pump in place, by simply removing face bolts and face plate, slipping old liner out, new one in (*5*).



SEND COUPON FOR FACTS!

Vanton Pump & Eqpt. Corp., Hillside, N. J. Dept. CEP-7

My pumping problem is .....

NAME .....

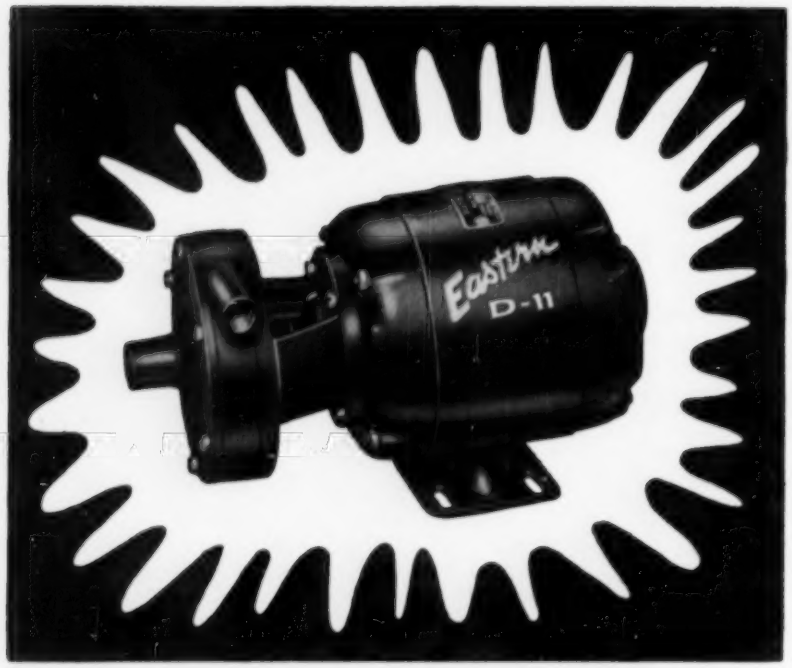
TITLE .....

COMPANY .....

ADDRESS .....

CITY ..... **STATE** .....

VANTON PUMP
and Equipment Corp. • Hillside, N. J.
DIVISION OF COOPER ALLOY CORP.



24,830 successful installations!

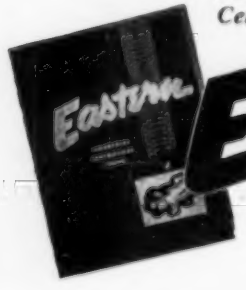
EASTERN D-11 CENTRIFUGAL PUMP

Why is the D-11 so successful among original equipment manufacturers? *Size and weight* make it ideal. The D-11 is the smallest, close-coupled, single-stage centrifugal pump available with an induction type motor. Eighteen pounds of compact design (9¾" x 4⅝") make it excel in industrial and process equipment, as well as laboratory service, and pilot plant operations.

SPECIAL METALS

A full selection of metals make the D-11 and other Eastern Centrifugal Pumps versatile performers. Available in 18-8 Type 303 and Type 316 Stainless Steel, Monel, Hastelloy "C", Cast Iron and Bronze, Eastern Pumps range from ⅛th to ¾ H.P. with capacities up to 70 G.P.M., pressures to 65 P.S.I.

For complete specifications on all Eastern Centrifugal Pumps, request Bulletin 120-A



Eastern INDUSTRIES, INC.
100 Skiff St., Hamden 14, Conn.

OVERSEAS NEWS

Hokushin Electric Works, Tokyo, Japan, will soon begin to manufacture substantially all the process instrumentation products of Fischer & Porter. A license agreement between the two companies has been signed, is waiting for validation by the Japanese Government. □

England's first synthetic rubber plant, being engineered and designed by Chemical Plants Division of Blaw-Knox for The International Synthetic Rubber Co., Ltd., will have a capacity of 50,000 long tons of GR-S a year. The plant will be adjacent to the refinery of Esso Petroleum Company, Ltd., which will supply the butadiene. □

Azienda Lavorazione Colori Resine e Affini, one of Italy's largest resin manufacturing concerns, will soon begin production of synthetic resins, copolymers, plasticizers and foundry core oils and binders based on research and know-how of Archer-Daniels-Midland. ADM has licensed the Italian firm. □

The Dead Sea Bromine Works, Ltd., of Israel, located on the site of one of the richest bromine deposits in the world, has appointed Aceto Chemicals as its U. S. representative. The unique position of the Israeli plant enables it to produce ethylene dibromide economically, efficiently, and at high quality. □

Chemstrand Corp. will be a minority shareholder in a newly-formed subsidiary of Societa Edison, Milan, Italy. The new subsidiary will manufacture acrylic fibers using the Chemstrand process under license from Chemstrand. Another subsidiary of Societa Edison recently started production of acrylonitrile in Italy. Fiber production is expected to begin within two years. □

A major acetylene plant will be built by the Engineering Division of Societe Belge de l'Azote et des Produits Chimiques du Marly (S.B.A.) for Houilleres du Bassin de Lorraine. The plant will be erected at Carling (Moselle) and is part of a large chemical program including, primarily, the production of acrylonitrile. □

A new British company, Chlorination Equipment Ltd., will manufacture and sell Fischer & Porter type chlorination equipment under the terms of an agreement between Fischer & Porter and the Paterson Engineering Co., Ltd., of London. □

"Batch-Type" Operation

is fine in

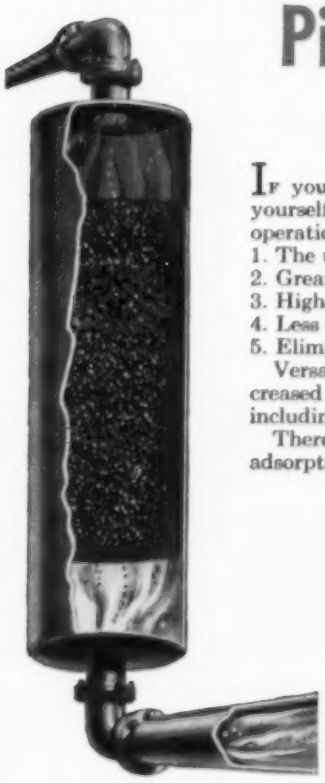
the kitchen...



But for Highest Adsorption Efficiency Specify

Pittsburgh Granular Carbons

IN A CONTINUOUS COLUMN SYSTEM



If your process utilizes activated carbon in a batch-type operation, you owe it to yourself to investigate the unique benefits of converting to a continuous column operation employing Pittsburgh Granular Activated Carbons. Such a system offers:

1. The ultimate in counter-current efficiency and simplicity of operation.
2. Greater capacity, lower carbon dosage, lower costs.
3. Higher product quality, better colors, higher purity.
4. Less equipment, less floor space, less maintenance required.
5. Elimination of slurrying and dusting problems inherent in powdered carbon systems.

Versatile, coal-derived Pittsburgh Granular Carbons in column systems have increased efficiency and lowered costs in a wide variety of industrial adsorption processes, including purification, decolorization and catalysis. And they can do the same for you!

There's a type of Pittsburgh Granular Carbon ideally suited to solve your particular adsorption problem. *A letter or call will bring you full particulars!*

Send for this Free Booklet

Write today for your copy of new "Pittsburgh Activated Carbons" booklet. Describes types and uses of Pittsburgh Carbons in vapor and liquid phase applications.

ACTIVATED CARBON DIVISION

PITTSBURGH COKE & CHEMICAL CO.

Grant Building • Pittsburgh 19, Pa.

WSW 6444

COAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON

(Advertisement)

E-D Filter Paper Makes Excellent Cover For Cloth Or Other Filter Media

Provides Greater Clarity Of Filtration And Prolongs Life Of Filter Medium

FILTERTOWN, USA. Field reports prove that there is an increasing use of E-D filter papers, with the greatest demand for grade # 953, as a cover for cloth or other filter media in industrial filtration. To date, this practice has been widely adopted in plants which process oils, including coconut, cod liver, corn, cooking, linseed, soybean, and vegetable oil. These plants manufacture margarine, salad oil and shortening, soaps, paint, varnish, and many other products.

Great Savings In Time And Money

Actual experience, in hundreds of cases, has proven to the satisfaction of production officials that it is far more economical to cover the cloth or other filter medium with E-D filter paper and then, when the press needs redressing, to simply peel off the paper, discard it, and replace with a clean E-D filter paper cover. Substantial savings in press running time are made.

E-D filter paper holds up solid particles to such a degree that there is often little need for recirculating the slurry to obtain an adequate cake deposit for clear filtration at the start of a cycle.

Moreover, the E-D filter paper protects the filter medium from slimy fines, thus prolonging its useful life, saving additional money on media expenditures. The cost of E-D filter paper is so little, in comparison with the cost of other filter media, that these savings are important.

Greater Clarity Of Filtrate Obtained

Because of its fine porosity and unique uniformity of furnish, grade #953—as well as the many other grades of E-D filter paper—obtains exceptional clarity of filtrate. Many degrees of rapidity and porosity are available in the more than 50 regular grades manufactured by The Eaton-Dikeman Company. Special grades are also made to meet individual requirements.

Free Samples Available

Actual tests made at the user's plant furnish convincing proof of the many advantages that are possible. Simply write for E-D's Filtration Analysis Report. When the necessary facts are supplied, you will receive several recommended grades, cut to your own size and specifications, at no charge. Make the necessary test runs and you will soon be able to determine the benefits for yourself. There is no charge or obligation for this service.

Write to Thomas H. Logan, Jr., care of The Eaton-Dikeman Company, Filtertown, Mount Holly Springs, Pennsylvania for prompt attention.

This company is the only company in America that is exclusively engaged in the manufacture of filter paper for science and industry. Authorized representatives and dealers are located in every section to provide service and helpful information on all problems relating to liquid filtration.

HEAT EXCHANGER STANDARDS

New A.I.Ch.E. Subcommittee on Standards for Shell and Tube Heat Exchangers took what could be unprecedented action at its recent meeting and endorsed the Manufacturing Chemists Association's action in asking the Chemical Industry Advisory Board to recommend that the American Standards Association initiate a project to develop standards for heat exchangers for chemical industry use. In essence, the Subcommittee decided not to develop its own standards for heat exchangers, but to work with A.S.A.

Specific recommendations were: 1) there is a need for expanding present standards in this field; 2) M.C.A.'s recommendation to C.I.A.B. that A.S.A. initiate work to improve standards be supported by A.I.Ch.E. Standards Committee; 3) A.I.Ch.E. Standards Committee should take an active role in A.S.A.'s project; and 4) the Standards Committee should bring A.S.A.'s attention to the need for provisions for prompt revision or addition to any code of standards developed.

The Chinese Institute of Engineers, a professional-cultural group particularly active in the New York area, held its 1957 annual meeting in New York City June 15. Technical papers read during the afternoon chemical engineering group session, chairmanned by L. C. Pan (Chemico), were: "Recent Advances in Laminated Plastics," Y. C. Tang (Standard Packing Corp.); and "Process Design," Utah Tsao (Lummus Co.). Banquet speaker was Monroe E. Spaght, executive vice-president, Shell Oil Co. (see Noted & Quoted, p. 30).

Professor J. C. Chu of the Chemical Engineering Department, Brooklyn Polytech, is general chairman of the C.I.E. of New York, and Andrew Ting (Chemico) is chairman of the chemical engineering division. □

The Patent Office in Washington, D. C., is still desperately in need of engineers and scientists to serve as Patent Examiners, according to the New York Patent Law Association. While delays in processing patent applications have been reduced somewhat recently, there is still a "log-jam" which works to the detriment of all industry and can only be relieved by more examiners. □

LUMMUS

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

385 Madison Avenue New York 17, N. Y.

LUMMUS BUILDING THREE SHELL PROCESS ETHYLENE OXIDE PLANTS

Two plants in U. S., one in England will be world's first to use Shell Development Co.'s direct oxidation process

Within the next year three new plants for making ethylene oxide by the Shell Process will come on-stream. All three are being designed, engineered and built by Lummus through whom the process is available. When completed they will be the first commercial scale plants to use the process developed by Shell Development Company.

In the Shell Process for making ethylene oxide, ethylene is reacted with oxygen over a silver catalyst in a fixed bed reactor. The Shell innovations, which have been thoroughly tested in pilot plants, offer several noteworthy advantages. Among these are high yields, and virtual elimination of the waste disposal problems encountered in the chlorohydrin process.

One of the new facilities is being built for Wyandotte Chemicals Corp. at Geismar, La., near Baton Rouge. Annual capacity will be 60,000,000 lbs. of high purity ethylene oxide, most of which will be converted to ethylene glycol by thermal hydration for industrial and antifreeze uses.

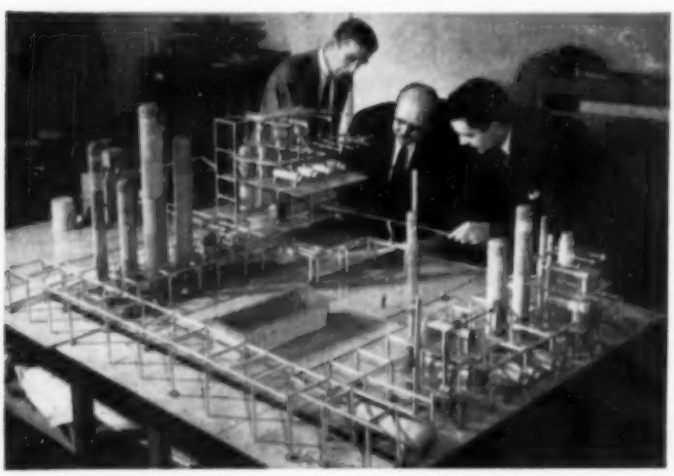
Lummus is building another 60,000,000 lb./year plant for Calcasieu Chemical Corp. at Lake Charles, La. Like Wyandotte's, it will have an ethylene glycol section.

The third plant, also a 60,000,000 lb./year unit, is being built at Partington, England for Petrochemicals, Ltd., one of the Royal Dutch Shell group companies.

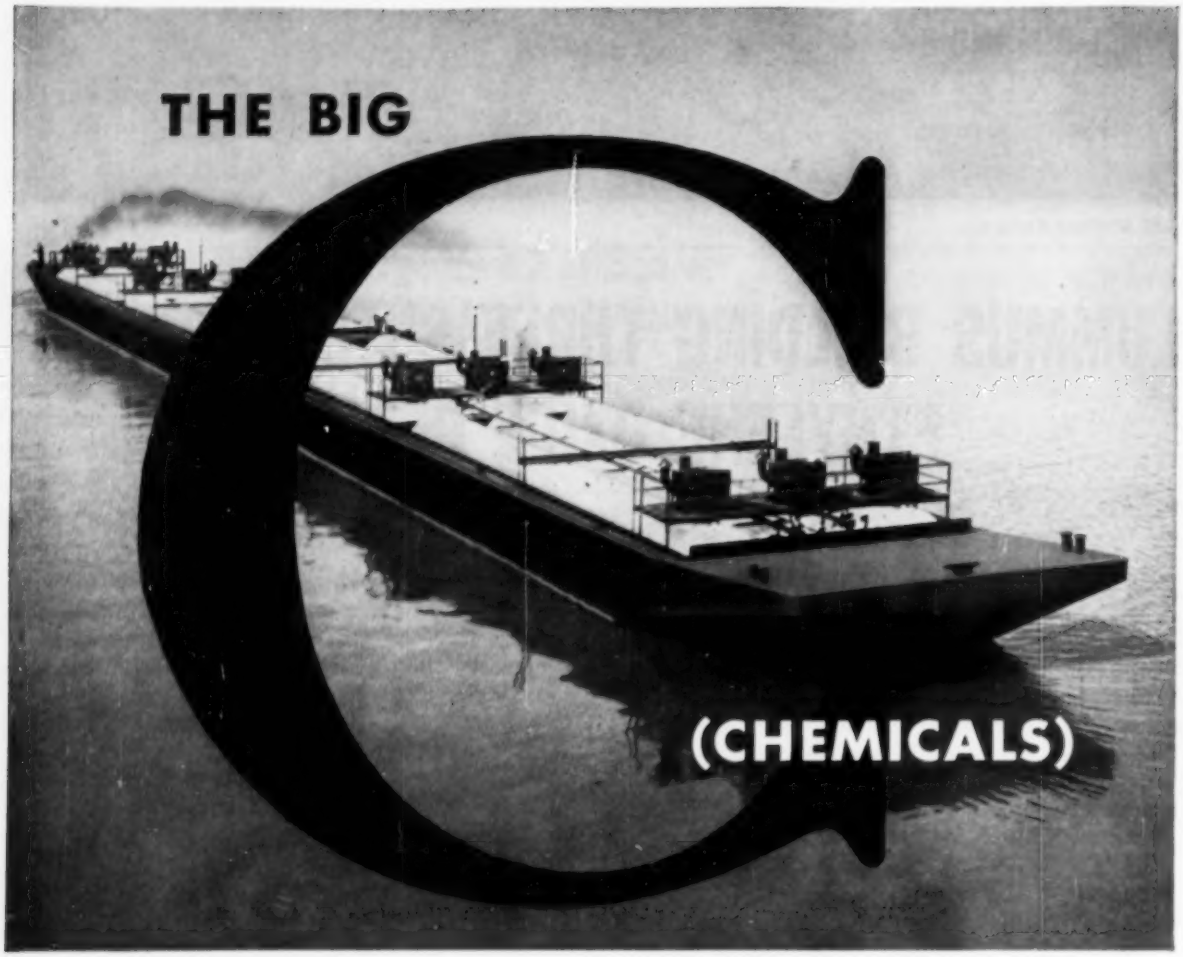
All three plants use oxygen, which requires less capital investment than the use of air.

Lummus is proud to be entrusted by Shell and these producers with the task of putting the Shell Process into full scale application. The experience of the Lummus organization — in plant design, engineering and construction — will merit your confidence too.

THE LUMMUS COMPANY, 385 Madison Avenue, New York 17, N.Y. *Engineering and Sales Offices and Subsidiaries:* New York, Houston, Montreal, London, Paris, The Hague, Bombay. *Sales Offices:* Chicago, Caracas. *Heat Exchanger Plant:* Honesdale, Pa. *Engineering Center:* Newark, N. J.



Lummus engineer points out on model, details of Wyandotte Chemicals' new ethylene oxide plant. Due onstream early in 1958, it will be first in U. S. to employ Shell Process.



and INGALLS BARGES

ECONOMICAL · PRACTICAL · SPECIALLY DESIGNED



To meet the ever growing needs and problems of chemical transportation, Ingalls specializes in building barges to your exact specifications and requirements. The first step in solving your waterways-transportation problem is discussing it with Ingalls today!

DESIGNERS & BUILDERS
of Offshore Service Vessels
Drilling and Commercial
Barges, Tankers, Naval
and Merchant Vessels.

INGALLS WORKBOATS

THE INGALLS SHIPBUILDING CORPORATION
Executive Offices: Birmingham, Alabama
Branch Offices: New York, Washington, New Orleans, Chicago, Philadelphia, Atlanta, Houston
Shipyards: Pascagoula, Mississippi; Decatur, Alabama
Subsidiary: Arnold V. Walker Shipyard, Inc., Pascagoula

ENGINEERS: for jobs with a future, contact Ingalls today.



The new Research Center of the Dravo Corp. is on Neville Island near Pittsburgh, Pa. In operation, the Center houses chemical, metallurgical, physical testing, heater, sintering and pelletizing, concrete and marine laboratories.

A high polymer alkyd technique which improves the properties of resins has been developed by Heyden Newport Chemical Corp. The new method for processing alkyl resins includes a step-wise esterfication of fatty acids that increases the proportion of high molecular weight polymers. □

A new research center for work on petrochemicals, plastics and related fields is being built at Wilton, Conn., by Escambia Bay Chemical Corp. □

A major addition to Stauffer Chemical's research laboratories at Richmond, Cal., will provide necessary additional facilities for the company's extensive research activities in the development of special metals, high energy chemical fuels, and new inorganic plastics. □

Titanium, zirconium and the Hastelloys may soon be on the market in the form of clad-steel plates for process equipment if the steady progress of development work at Lukens Steel Co. continues. The potential of the cheaper, bi-metallic plates is great. According to Lukens, "Zirconium-clad would have a number of atomic applications, Hastelloy-clads would have many applications in various petrochemical processes, and titanium-clads would be applicable in acid processes and for service involving chlorides." □

One of the west's largest fabricators of pressure vessels, tanks and specialty metal products has formed a new research subsidiary. The new subsidiary is Eaton Research and Development Co. formed by Eaton Metal Products Co. of Denver, Colo. Primary purpose of the new company will be to engage in research and development work in chemical and mechanical engineering, physics and related fields for private industry and agencies of the Federal Govt. □



Verti-Line®

PROCESS PUMPS

in

CHEMICAL PLANT

At the Brea Chemical Company in Southern California two 50 HP Verti-Line process pumps are handling 1800 GPM at 105°F, returning water from the ammonia synthesis area to cooling towers. *These units have been operating 24 hours a day since May, 1954 – without maintenance expense other than normal service.*

Over 100,000 satisfied vertical pump users agree there's no pump like Verti-Line for low first cost, economical operation, and negligible maintenance.

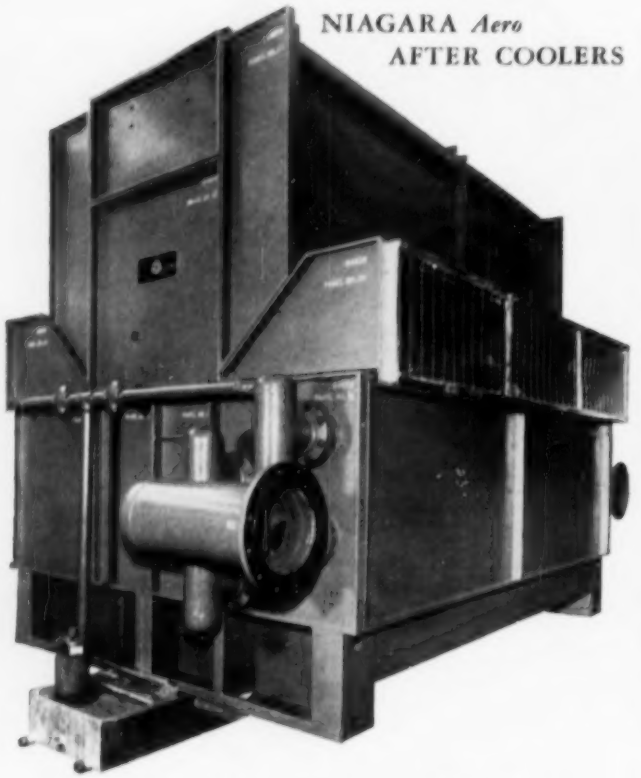
IF YOUR NEEDS INCLUDE PROCESS PUMPS, IT WILL PAY YOU TO INVESTIGATE VERTI-LINE BEFORE YOU BUY

Verti-Line Pumps are exclusive products of

LAYNE & BOWLER PUMP COMPANY

general offices & main plant

2943 VAIL AVENUE • LOS ANGELES 22, CALIFORNIA



ECONOMICAL COOLING OF GASES and COMPRESSED AIR

● Cooling gases or cooling and removing moisture from compressed air, the Niagara *Aero* After Cooler offers the most economical and trustworthy method. Cooling by evaporation in a closed system, it brings the gas or compressed air to a point close to the ambient temperature, effectively preventing further condensation of moisture in the air lines. It is a self-contained system, independent of any large supply cooling water, solving the problems of water supply and disposal.

Cooling-water savings and power-cost savings in operation return your equipment costs in less than two years. New sectional design reduces the first cost, saves you much money in freight and installation labor and in the expense of upkeep.

Niagara *Aero* After Cooler systems have proven most successful in large plant power and process installations and in air and gas liquefaction applications.

Write for Descriptive Bulletin 130

NIAGARA BLOWER COMPANY

Dept. E.P.-7, 405 Lexington Ave. New York 17, N. Y.

District Engineers in Principal Cities of U. S. and Canada

FUTURE MEETINGS



The 8-mile long $50 million Chesapeake Bay Bridge near Baltimore is a connecting link in the growing Atlantic Coast expressway system.

MEETINGS **SYMPOSIA**

■ **BALTIMORE, MD.**

September 15-18, 1957. Lord Baltimore Hotel. See complete program on page 106 et seq.

■ **STATE COLLEGE, PA.**

August 11-15, 1957. Pennsylvania State University.

First National Conference on Heat Transfer. Sponsors: A.I.Ch.E., A.S.M.E., & College of Eng. & Arch., Penn State Univ. Purpose is to provide a forum and an opportunity to exchange ideas and data on the industrial applications of heat transfer.

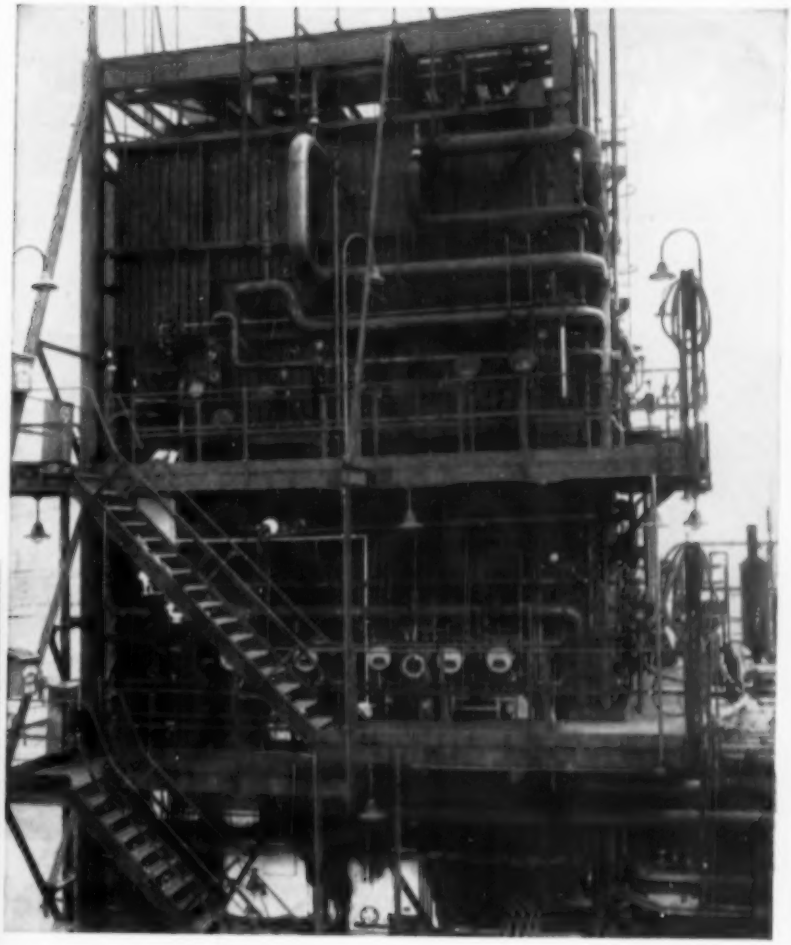
● Monday Morning, Aug. 12, Session 1: Study of Heat Transfer and Pressure Drop under Conditions of Laminar Flow in the Shell Side of Cross-Baffled Heat Exchangers, F. L. Test, Univ. of R. I.; Dynamic Response of Heat Exchangers Having Internal Heat Sources, Part 2, Vedat S. Artaci & John A. Clark, Univ. of Mich.; New Method of Heat Exchanger Design, R. S. Fairall, Garrett Corp., Los Angeles, Calif.

● Monday Afternoon, Aug. 12, Session 2: Heat Transfer to Liquid Metals, P. S. Lykoudis, R. Viskanta, & Y. S. Touloukian, Purdue Univ.; Heat Transfer to Fluids with Low Prandtl Numbers for Flow Through Tube Banks, R. D. Cess & R. J. Grosh, Purdue Univ.; Heat Transfer Rates to Cross-Flowing Mercury in a Staggered Tube Bank-2, C. L. Richard, O. E. Dwyer, Brookhaven, & D. Dropkin, Cornell Univ.

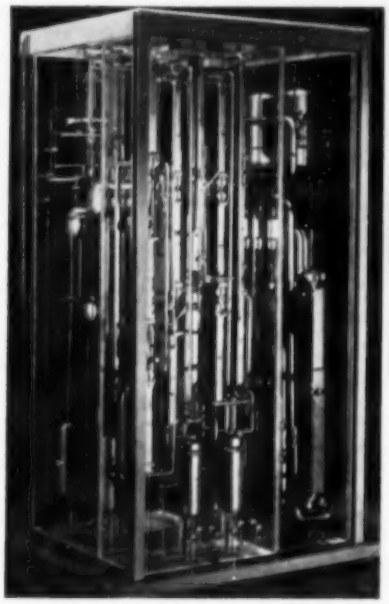
● Monday Afternoon, Aug. 12, Session 3: Quasi-Linear Heat Flow, N. E. Friedmann, Litton Industries, Beverly Hills, Calif.; Influence of Gradient Temperature Fields on Thermocouple Measurements, N. R. Johnson, A. S. Weinstein & F. Osterle, Carnegie Tech; Effectiveness of Stub Fins as Determined by the Teledeltes Paper Analog, F. Landis & T. Zupnik, New York Univ.

● Tuesday, Aug. 13, Session 4: Radiant Heat Exchange in a Gas-Filled Enclosure, H. C. Hottel & E. S. Cohen, M.I.T.; Heat Transfer Studies of Naval Boilers, L. Cohen & W. A. Fritz, U. S. Naval Boiler and Turbine Lab., Naval Base, Philadelphia; Development of Ceramic Insulating Materials and High Temperature Use, W. D. Kingery, J. D. Klein, M.I.T., & M. C. McQuarrie, Penn State Univ.

(Continued on page 116)



"Cold Box" is part of an ammonia plant. The Atlantic Refining Company built it to use the once-burned hydrogen by-product of the catalytic reforming of high octane gasoline. Here the hydrogen by-product is purified and nitrogen is recovered by liquefying and fractionating air from the atmosphere.



Model of Plant shows maze of stainless steel pipes and pressure vessels used for nitrogen separation and hydrogen washing. Actual plant was built by Hydrocarbon Research Inc., N. Y., with a capacity of 100 tons of anhydrous ammonia per day.

Another important job for nickel-containing Stainless Steel because...

The Problem: —325°F

This "cold-box" separates nitrogen from the air and purifies hydrogen. It's a step in the production of anhydrous ammonia at The Atlantic Refining Company's South Philadelphia plant.

Here, the temperature dips as low as *minus* 325°F. Much of the equipment operates at *minus* 140°F.

At those temperatures carbon steel is as brittle as glass. You can see why equipment has to be made of special material. And it is.

Designers of the plant knew that a safe and practical material to use for much of the equipment was austenitic chromium-nickel stainless steel.

With 8% nickel, stainless steel has the ability to retain toughness and ductility right down to as close as we can get to absolute zero. And 18-8 stainless steel has the necessary strength to handle the relatively high (100 to 440 psi) operating pressures.

Do you have a low temperature problem? If so, you'll find "Properties of Stainless Steel at Low Temperatures" extremely helpful. And Inco's Development and Research Division is ready to help you.

INCO THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

Struthers Wells

STOCK Heat Exchangers Save you money!



Code Equipment at Production Prices

Struthers Wells standard stock heat exchangers have secured a wide acceptance in the process industries.

The illustration shows a partial view of units currently in stock. Equipment is available from stock in sizes from 20 to 300 square feet of surface—including fixed tube sheet, floating head and U-tube units.

Condensers, coolers, heaters, and reboilers can be supplied in single and multi-pass tube arrangement.

Standard heat exchanger construction includes materials of carbon steel, non-ferrous alloy, and stainless alloys Type 304 and Type 316. Equipment meets highest construction standards, including ASME Code and TEMA Class A.

Standardization of design and quantity production enables us to offer this equipment at a very reasonable cost.

Price sheets and standard data are available on request; please address us on your letterhead.

STRUTHERS WELLS PRODUCTS

PROCESSING EQUIPMENT DIVISION

Crystallizers . . . Direct Fired Heaters . . . Evaporators . . . Heat Exchangers . . . Mixing and Blending Units . . . Quick Opening Doors . . . Special Carbon and Alloy Processing Vessels . . . Synthesis Converters

BOILER DIVISION

BOILERS for Power and Heat . . . High and Low Pressure . . . Water Tube . . . Fire Tube . . . Package Units

FORGE DIVISION

Crankshafts . . . Pressure Vessels . . . Hydraulic Cylinders . . . Shafting . . . Straightening and Back-up Rolls

MACHINERY DIVISION

MACHINERY for Sheet and Structural Metal Forming . . . Tangent Benders . . . Folding Machines . . . Roller Table and Tumble Die Bending Machines . . . Press Brakes . . . Punching and Notching Machines . . . Forming Dies

ANY SIZE AVAILABLE FOR QUICK DELIVERY

STRUTHERS WELLS *Corporation*

Struthers Wells

WARREN, PA.

Plants at Warren, Pa. and Titusville, Pa.

Offices in Principal Cities

BALTIMORE

ON THE MAP . . .

1 **Lord Baltimore Hotel**—September Meeting headquarters
2 **American Agricultural Chemical Co.**—fertilizer, superphosphates
3 **American Alcolac Corp.**—synthetic detergent base
4 **Armour & Co.**—fertilizers
5 **C. M. Athey Paint Co.**—paints
6 **Baltimore Paint & Color Works**—paints, varnishes
7 **Baugh & Sons**—fertilizers
8 **Bethlehem Steel**—sulfuric, coal chemicals
9 **Bloede Co.**—gums, glue, sizing, pastes
10 **Bruning Bros.**—paints, enamel
11 **Bunting Chemical Co.**—drugs
12 **Continental Oil**—synthetic detergent base
13 **Cooperative Fertilizer Service of Baltimore**—fertilizers
14 **Davis Co.**—paints
15 **Davison Chemical Co. (W. R. Grace)**—sulfuric, fertilizers, silica gel, catalysts.
16, 17 **Du Pont**—paint pigments, titanium dioxide
18 **Emerson Drug Co.**—drug products
19 **Fairfield Chemical Div. (Food Machinery & Chem.)**—insecticide chemicals
20 **Farboil Paint Co.**—paints
21 **Fertilizer Mfg. Cooperative**—fertilizer, superphosphate
22 **General Chemical Div. (Allied)**—insecticides
23, 24 **Glidden Co.**—pigments, titanium dioxide
25, 26 **Griffith & Boyd Div. (Summers Fertilizer)**—fertilizers
27 **Hanline Bros.**—paints
28 **Hynson, Westcott & Dunning**—pharmaceuticals
29 **Lasting Products Co.**—paints
30 **Lever Bros.**—soaps, detergents
31 **McCormick & Co.**—synthetic extracts
32, 33 **Mutual Chemical Div. (Allied)**—chromium chemicals
34 **O'Brien Corp.**—paints
35 **Olin Mathieson**—fertilizers, sulfuric, alum, superphosphate, antifreeze
36 **Pemco Corp.**—frits, glazes, colors
37 **Philadelphia Quartz**—silicates
38 **Procter & Gamble**—soaps, detergents
39 **Rasin-Monumental Co. (Fertilizer Div., Virginia-Carolina Chemical)**—fertilizers
40 **Ronald Research Lab.**—vitamins
41 **Royster Guano Co.**—fertilizers, superphosphate
42 **Stalfort Pressure Pack**—aerosol products
43 **Swift & Co.**—fertilizers
44 **Young Co.**—licorice, logwood extract
45 **Young Aniline Works**—aniline dyes

PLANT TRIPS

Monday, September 16
Food Machinery & Chemical Corp. ..... 9:00 a.m.
Allied Chemical & Dye Corp. ..... 9:00 a.m.
Fort Detrick ..... 12:30 p.m.

Tuesday, September 17
American Sugar Refining Co. ..... 9:00 a.m.
Fort Detrick ..... 12:30 p.m.
Army Chemical Center .. 12:30 p.m.

Wednesday, September 18
Calvert Distilling Co. ... 8:30 a.m.
Davison Chemical Co. .. 8:30 a.m.
Bethlehem Steel Co. .... 12:30 p.m.
Glenn L. Martin Co. .... 12:30 p.m.



. . . a big technical program deep in the heart of

CHEMICAL COUNTRY

J. R. Mecredy, W. K. O'Loughlin and S. C. Streep

Davison Chemical Co.
Baltimore, Maryland

With Wilmington only about 60 miles away, and a major chemical industry in Baltimore itself, the chemical engineer will be deep in the heart of chemical country at A.I.Ch.E.'s National Meeting, September 15-18. There will be one of the bigger plant trip lists and a really provocative and informative technical program.

A glance at the map will give an idea of the size and scope of Baltimore's chemical industry. There are more than 40 chemical plants in the city, plus the largest steel plant in the world, the Martin Co., leading the way to outer space with Project Vanguard (you'll hear all about the chemical engineering aspects of Vanguard in the technical program), a major oil refinery, one of the largest airplane fabricating plants, and the two largest Army Chemical Corps installations. This time there is an extra urgency to the warning "make your reservations promptly and soon"—the plant trips are limited.

Low Temperature—Expanding Field

When new techniques begin to grow in scope and importance the chemical engineer grows with them. Today low-temperature processing is growing rapidly and steadily, was heavily covered in the June issue of *CEP*, a "get-acquainted-with-the-field" session was held at the Boston meeting. Here is the second session—and this time the engineers are getting down to work with processing data, design considerations, and large-scale applications. There will be a method for removing hydrogen sulfide and carbon dioxide from natural gas; a new instrument for low temperature viscosity work; commercial scale study of ultra-low temperature refrigeration and processing plants; a major special refrigeration system using halocarbons.

But new processing techniques have their problems: one of these in low-temperature work is safety. At Boston

BALTIMORE . . .

(Continued from page 105)

there was one paper on air plant safety—it drew such a rousing response that the program committee at Baltimore has set up three whole sessions. Two will get the experts from air plants all over the country to talk about every aspect of air plant safety problems, and the third will do the same for ammonia plants. These are "everybody bring slides and talk" sessions, designed for operating people in the field itself, will cover the "why" of recent air plant explosions (nobody seems to agree exactly), will try to get everybody to tell what they know so that the same mistakes are not made twice. Other chemical engineers will get a lot out of these two. Pressure vessels will get a going over, compressors, contaminated areas and what to do about them, and a lot more.

Three Fields Are One

Adsorption, Dialysis, and Ion Exchange may not sound like fireworks, but that is what they are going to provide at Baltimore. It's a big session (four parts, from the real leaders in the fields), and the crux is simply this: fifteen years of work in the separate fields has led many engineers to the perhaps controversial conclusion that they are in many ways one field!

Arguments are impressive: the three fields use the same equipment, media, and mathematics. Some unfamiliar concepts are going to be brought out: adsorption using membranes, dialysis using granular materials, ion exchange using membranes. Of course there are differences in the fields—but from the chemical engineering viewpoint, the practical application in process equipment, you'll probably be startled by the similarities developed in these sessions.

Chemical Propellants—Project Vanguard

Every chemical engineer is interested in Project Vanguard (the launching of the first space satellite). The Martin Co. of Baltimore is prime contractor and it will be represented at one of the two sessions on jet propulsion—with an emphasis on fuels and chemical processing. Potential rocket and jet market is above $2 million a year, a good part of that is for fuels. The fuels are chemical, plants to make them are chemical. (Recent CCDA meeting was devoted entirely to these fuels.) Tormey's paper will bring you up to date on chemical fuel principles. Then the boron hydrides will be discussed, unsymmetrical dimethylhydrazine (to be used in the second stage rocket of Vanguard), anhydrous H_2O_2, and more. Processing, handling, and properties of the new propellants will be stressed, the chemical engineer's place will be shown. The techniques involved are basic, any polymer engineer, for example, can learn a lot from discussions of solid propellants.

Drying and Chlor-Alkali Industry Future

Here are two basics for chemical engineers. Drying has been missing

---

MEETING PROGRAM . . .

SUNDAY, SEPTEMBER 15

ENGINEERS OVERSEAS, AN IMPORTANT PHASE OF A POSTWAR TREND, R. Hope, Davison Chemical Corp., Baltimore, Md., chairman.

Living and working conditions, personnel problems, and other problems of chemical engineers working in foreign countries will be analyzed by a panel of experts. The panel will be announced in August CEP.

MONDAY, SEPTEMBER 16

ADSORPTION, DIALYSIS, AND ION EXCHANGE, G. P. Monet, Du Pont, Wilmington, Del., chairman.

Introduction—Similarities in Adsorption, Dialysis, and Ion Exchange, G. P. Monet.

While the three fields differ in the physicochemical way sorption occurs, from the chemical engineering viewpoint the three fields are quite similar.

SESSION I—GRANULAR PROCESSES, ADSORPTION, L. Lapidus, Princeton U., Princeton, N. J., presiding.

Adsorption Equilibria, D. P. Graham, Organic Chemicals Dept., Du Pont, Wilmington, Del.

The nature and energetics of adsorption emphasizing use in clarification or fractionation, with experimental techniques for obtaining equilibrium data, and the factors which should be considered in selecting an adsorbent for a specific purpose.

The Kinetics of Batchwise Adsorption of Dichlorophenol on Activated Carbon, S. B. Smith, A. X. Hiltgen, and A. J. Juhola, Pittsburgh Coke and Chemical Co., Pittsburgh, Pa.

The effects of adsorbent structure, particle size, initial adsorbate concentration, temperature, and adsorbent-solution ratio on the rate of adsorbtion of 2,4-dichlorophenol from aqueous solution by various granular activated carbons. Mathematical treatments of previous investigators proved unsatisfactory, a semi-empirical treatment is proposed.

Deactivation and Reactivation Phenomena During Charcoal Adsorption of Hydrocarbon Gases, R. F. Baddour, MIT, and R. L. Geddes, Stone & Webster Eng'g. Corp., Boston, Mass.

Experiments under varying conditions on the effect of hydrocarbon pyrolysis gas on the adsorptive capacity of activated petroleum coke in an effort to gain information useful in commercial design work.

Molecular Sieves, G. J. Griesmer, R. A. Jones, and H. Lautensack, Linde Co. (Union Carbide), Tonawanda, N. Y.

Nature and properties of molecular sieves, experimental data to illustrate their advantages, commercial details of applications, future applications potential.

GENERAL PAPERS I (Simultaneous with Adsorption Session), E. L. Knoedler, Jr., S. T. Powell, Baltimore, Md., chairman.

Thermal Entrance Region in Fully Developed Flow, P. H. Abbrecht, Minn. Mining & Mfg., Detroit, Mich., and S. W. Churchill, Univ. of Mich., Ann Arbor, Mich.

Extensive and detailed experimental study of temperature profile and local rate of heat transfer from the wall at various tube diameters for air in fully developed turbulent flow.

Propane Pyrolysis in a Molten Lead Bath Commercial Ethylene Production, J. R. Fair, Monsanto, Dayton, Ohio; J. W. Mayers, Pittsburgh Coke and Chemical, Pittsburgh, Pa.; and W. H. Lane, Monsanto, Texas City, Tex.

Results of a plant-scale research program with correlations based on significant operating variables. Aspects of heat transfer and mechanical operation are discussed.

Hydrogenation of Carbon Monoxide on a Steel Catalyst, R. H. Schatz, Esso Research & Eng'g., Linden, N. J.; and R. R. White, Univ. of Mich., Ann Arbor, Mich.

The hydrogenation of carbon monoxide on a steel catalyst to form methane was studied over the temperature range 800° to 1250° F. at a pressure of 31 atm. using feed gas containing 30% to 56% carbon monoxide.

Continuous Reactor Design, Theory and Practice, R. E. Greenhalgh, R. L. Johnson, and H. D. Nott, Dow Corning, Midland, Mich.

Theoretical concepts currently in use to predict conversions are described, simple and general methods of calculation will aid the designer in understanding the peculiarities of a system.

ADSORPTION, DIALYSIS AND ION EXCHANGE—PART II, GRANULAR PROCESSES—ION EXCHANGE, W. A. Selke, Peter J. Schweitzer, Inc., Lee, Mass., presiding.

Application of Ion Exchange Equilibrium Relationships to Process Design, N. W. Frisch and F. X. McGarvey, Rohm & Haas Co., Philadelphia, Pa.

The formulation of ion exchange equilibria expressions to represent the behavior of an ion-exchange resin with an ionic solution. The examination of the factors which influence the selectivity of a resin of given functional structure.

Kinetic Relationships for Ion-Exhange Processes, T. Vermeulen, U. of Cal., Berkeley, Cal., and N. K. Hiester, Stanford Research Institute, Menlo Park, Cal.

Fundamental considerations of equilibrium, diffusional mechanisms, and stoichiometry permit the prediction of column performance over a wide range of variables, based upon limited experimental data for the particular solute sorbent system involved.

Ion Exchange Kinetics, R. L. Moison and H. A. O'Hern, Jr., Du Pont, Wilmington, Del.

New data on ion exchange in deep, fixed-bed equipment. The data for favorable equilibria, together with similar results in the literature, are correlated by a variation of the "exchange zone" concept of Michaels.

Semi-Continuous Countercurrent Apparatus for Contacting Granular Solids and Solution, C. W. Hancher, ORNL, Oak Ridge, Tenn., and S. Jury, U. of Tenn., Knoxville, Tenn.

Progress in the field of semi-continuous

from the program for some time, new developments are numerous. Fundamental work, the kind you must have to solve the practical problems, has some new developments to show the engineer—including work on sublimation, evaporation and spray drying. Latest advances in pilot work with spray dryers and batch freeze-drying will be shown, and the Swenson Evaporator industrial work on spray dryers is going to get a lot of attention (it's a practical design paper, should be something to take home.)

As for the chlor-caustic industry, what chemical engineer is not interested in it? And today there's a problem—the balance between chlorine and caustic soda. Either we're going to have to make more soda ash from cell liquor or slow down on chlorine, and the experts say we won't be slowing down on chlorine. Right now only one plant is making soda ash from cell liquor. How many more will there be? Rayon tire cord seems on the way out—what about the tonnage of caustic used there? Then there are new cells and larger cells, engineering problems of high importance.



View of the campus at Johns Hopkins University.

Direct Operating Labor Costs

Labor costs are too frequently taken for granted, insufficient emphasis is placed on their control, particularly by young engineers. And there is very little data available for estimating labor requirements. There will be very few bosses who will want their engineers to miss this one, what with industry everywhere driving to reduce costs and increase profits. Then there's the rapidly growing problem of the hard-headed estimation of whether X-dollars spent on automation is really a cost saving when compared to Y-dollars actually spent for the labor the automation saves. It's hard to judge how valuable, or impractical, an automation step might be unless the engineer really can estimate his direct operating labor costs. There is no standard technique, the papers in this session will present a lot of different methods and theories.

The Overseas Engineer

The Sunday panel discussion will gather together four chemical engineers who know the score on "Engineers Overseas, An Important Phase of a Postwar Trend." No one is an island anymore, you never know when it will be your turn to go abroad to work.

Entertainment—The Ladies

Monday and Tuesday's luncheons are going to have two top industry leaders as speakers (the committee is keeping their names secret until next month), and Monday night everyone boards the *Bay Belle* for a wine, dine, and dance cruise down Chesapeake Bay. Then comes the Tuesday evening banquet—and Maryland is world-famous for its cooking.

The ladies will not be neglected (we covered that last month), so just a reminder—bring the family. Baltimore is waiting for them with open arms and fabulous entertainment.

---

countercurrent ion exchange at Oak Ridge National Lab. A general theory of hydraulics and pressure drops in continuous and semi-continuous contactors is presented.

TRENDS IN THE CHLOR-ALKALI INDUSTRY, (Simultaneous with Ion Exchange Session), H. W. Zabel, Roger Williams Technical and Economic Services, Inc., Princeton, N. J., chairman.

Trends in the Chlor-Alkali Industry, End Use, T. A. Sheets, Diamond Alkali Co., Painsville, Ohio.

Detailed analysis of the future market prospects for chlorine and caustic soda. Lost markets will be more than compensated by new ones, such as the new metals as a chlorine market and alkaline pulping methods in the paper industry for caustic.

Trends in the Chlor-Alkali Industry, Technology, R. B. MacMullin, R. B. MacMullin Associates, Niagara Falls, N. Y.

Larger cell sizes are coming. Salt and brine purification methods will be tailor-made for each project. Purification of diaphragm cell caustic will be evaded by use of mercury cells.

The Interrelationship Between the Chlor-Alkali and the Soda Ash Industries, M. E. Clark, Frontier Chemical Co., Wichita, Kansas, and C. Gerlach, Wyandotte Chemical Co., Wyandotte, Mich.

Demand for chlorine has increased to the point where caustic is in over-supply. Result: instead of making caustic by liming soda-ash, soda-ash is now being sold on the market, one plant is already making soda-ash from caustic soda cell liquor.

TUESDAY, SEPTEMBER 17

JET PROPULSION—I, C. J. Marsel, New York Univ., N. Y., chairman.

Introduction to the Chemical Engineering of Liquid Rocket Propellants, J. F. Tormey, Rocketdyne, Canoga Park, Cal.

A summary of principles fundamental to the understanding of rocket propellant thermochemistry and performance, with emphasis on combustion chamber temperature and molecular weight of exhaust products.

Technology of Boron Hydrides, C. J. Major, American Potash and Chemical Corp., Henderson, Nev.

The unclassified physical, chemical, and thermodynamic data, typical chemical reactions, classical methods of preparation, methods of analysis and detection, handling techniques, and materials of construction for handling all the boron hydrides.

High Energy Hydrocarbon Fuels, J. Happel and C. J. Marsel, New York Univ., New York, N. Y.

Additional energy can be imparted to the carbon-hydrogen system by formation of a strained ring such as cyclopropane, or unsaturated bonds such as the acetylenic linkage. Production of such high energy compounds for fuels using petroleum derived raw materials is discussed, commercial process possibilities outlined.

Anhydrous Hydrogen Peroxide as a Propellant, R. Bloom, Jr., and W. J. Brunsvold, Chemical Division, Food Machinery & Chemical Corp., Buffalo, N. Y.

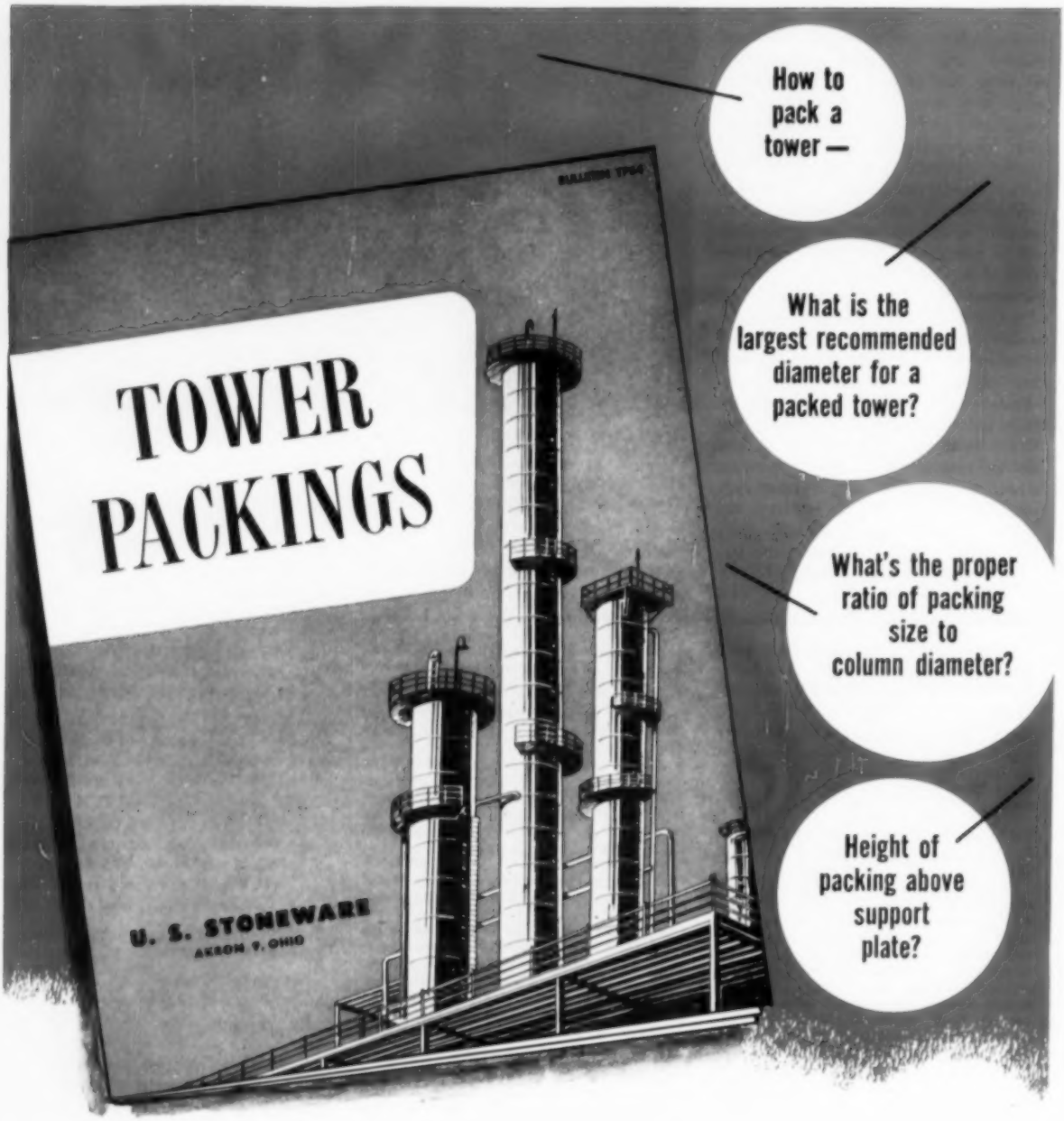
Brief outline of method of production, detailed study of the use of anhydrous hydrogen peroxide compared to 90% H_2O_2 as a monopropellant and as an oxidant in bi-propellant system. Some of the latest advances in handling and use are discussed, such as the British peroxide-powered submarine.

ADSORPTION, DIALYSIS AND ION EXCHANGE—PART III, MEMBRANE PROCESSES, (Simultaneous with Jet Propulsion-I and Ammonia Plant Safety Session) A. G. Winger, Rohm & Haas Co., Philadelphia, Pa., presiding.

Gaseous Diffusion Through Microporous and Adsorbent Membranes, K. Kammermeyer, State Univ. of Iowa, Iowa City, Iowa.

Microporous and adsorbent membranes typify selective barriers. The flow through such barriers is by molecular flow and surface flow, the interrelationship which is

(Continued on page 109)



Such helpful information as this is contained in a new booklet (TP54) which we have prepared to describe the physical and chemical data on Tower Packings. It is free on request to chemical engineers, engineering students and colleges.

Data also includes sizes, surface area, number per cubic foot, percentage of free gas space, etc., on Raschig Rings (ceramic, metal and carbon), Intalox Saddle Packing, Berl Saddles, Lessing Rings, Cross-Partition Rings, Spiral Rings, and Metallic Pall Rings.

Write for it today. Address Dept. CE-857
The U. S. Stoneware Co., Akron 9, Ohio

U. S. STONEWARE
AKRON 9, OHIO

51-P

BALTIMORE PROGRAM

(Continued from page 107)

elucidated and the various factors which control the respective flow components discussed.

Dialysis, J. A. Lane and J. W. Riggle, Du Pont, Wilmington, Del.

Methods and equations for estimating the over-all dialysis coefficients for the dialysis of a single electrolyte, or a single electrolyte and many non-electrolytes from the physical properties of the dialysis membrane and the diffusion coefficient of the dialyzing material. Considerations in the commercial design of equipment.

Molecular Separations by Solution Ultra-filtration, W. E. Henderson, Visking Co., (Union Carbide), Chicago, Ill. and C. M. Sliepcevich, Univ. of Oklahoma, Norman, Okla.

A detailed investigation to determine the factors which control the retention of non-electrolytes by ultrafiltration membranes having heteregeneous pore structures.

Applications of Ion-Exchange Membranes in Electrodialysis, E. A. Mason, MIT, Cambridge, Mass., and W. Juda, Ionics, Inc., Cambridge, Mass.

Various typical examples of membrane cell configurations used for electrodialysis are presented to show the versatility of application of these new materials.

SAFETY IN AIR AND AMMONIA PLANTS—SESSION I, AMMONIA PLANT SAFETY (Simultaneous with Jet Propulsion and Membrane Sessions) H. E. Maune, Mississippi River Chemical Co., Crystal City, Mo.

These sessions will be wide-open group discussions based loosely on planned agenda. Each topic on the agenda will be introduced with a few remarks by the chairman or his delegate and then will be thrown open to discussion from the floor. On the agenda are: 1) metal inspections of vessels and piping; 2) handling of spent catalyst; 3) welding and burning in danger areas; 4) nitriding problems in vessels and piping; 5) safe design in high pressure compressors.

Those planning to speak should notify the chairman in writing. Slide projectors will be available, their use is encouraged.

DIRECT OPERATING LABOR COSTS IN CHEMICAL PROCESS PLANTS, J. Happel, New York Univ., New York, N. Y., chairman.

Management Engineering Analysis of Direct Operating Labor Costs in a Chemical Plant, F. Gropper, Du Pont, Wilmington, Del.

Control of labor costs in a chemical plant by utilizing a number of well established management techniques including process methods, labor measurement, standard costs, incentives, and employee participation plans.

An Industrial Engineering Approach to Estimating Direct Operating Labor Requirement for Chemical Processes, T. B. Haines, Dow Chemical, Midland, Mich.

A new kind of practical approach to direct labor requirements through the use of standard time values obtained during work measurement or wage incentive studies. Standard time values will be explained.

Production Capacity and Work Load Analysis, R. S. Wobus, Monsanto, St. Louis, Mo.

A less detailed procedure for estimating labor requirements as a guide for: 1) estimating labor and equipment requirements for a new manufacturing process; 2) determining capacity and work load for an existing manufacturing process; 3) providing a basis for discussions with a union com-

(Continued on page 110)



HIGH-PRESSURE

NEEDLE VALVES

FOR REFINERIES

AND CHEMICAL PLANTS

BIG Needle or other type valves to your own specifications or requirements.

SMALL Forged valves in ¼" - ⅜" - ½" or ¾" sizes for high-pressure throttling, gauging or sampling services. The safety bonnet type meets exacting safety requirements. Available in 416 Stainless Steel or other alloys to special order.

CHEMICAL ENGINEERS... write today for illustrated Bulletin 101.

SPINDLER VALVES and other specialties since 1894

August Spindler & Sons, Inc.

Mercer Street, Jersey City 2, New Jersey

BARCO Swing Joints and Assemblies



for Loading and Unloading Lines

5 Reasons for SUPERIORITY!

1. **BALL BEARING AND O-RING EQUIPPED**—Suitable for handling solvents, naphtha, alcohol, gasoline, liquefied petroleum gases, carbon tetrachloride and many other fluids.
2. **LARGE BEARING SURFACE**—Barco's bearing design provides adequate support for lengths of piping. Minimizes bearing pressures and wear.
3. **CONTROLLED TORQUE**—No annoying, uncontrolled swinging of lines. They swing easily but stay put.
4. **LONG LIFE**—New "Bar-Moly" dry lubricant process gives a permanent anti-galling, corrosive-resistant finish to moving parts. This, combined with routine lubrication, insures longest possible maintenance-free service.
5. **EASY MAINTENANCE**—Joints can be disassembled for inspection without disconnecting piping. O-rings are easily renewable in the field. Frequent greasing not required to maintain sealing.

The Barco line is complete with single swing, double swing, and counter-balance styles and assemblies to meet every need. Sizes 1", 1½", 2", 2½", 3", 4", 6" and 10". All steel or malleable iron. Send for latest Catalog No. 400 containing engineering and ordering information. *Worldwide sales and service.*



BARCO MANUFACTURING CO.
5601H HOUGH STREET
Barrington, Illinois

BALTIMORE PROGRAM

(Continued from page 109)

mittee covering the size and classifications of the work force needed for a given operation.

Human Engineering and Direct Operating Labor Costs in Chemical Plants, B. L. Cusack, New York Univ., New York, N. Y.

The technique of human engineering—what it is, how it works, what is behind it. The problems arising from automation in the chemical industry will be discussed.

ADSORPTION, DIALYSIS, AND ION EXCHANGE—PART IV, MEMBRANE PROCESSES (CONT.) (Simultaneous with Labor Cost and Low Temperature Sessions), A. G. Winger, presiding.

Design of Electrodialysis Equipment, E. A. Mason and T. A. Kirkham, Ionics, Inc., Cambridge, Mass.

The principles of operation, design and cost evaluation of equipment using ion exchange membranes for electrodialysis applications. Design equations for prediction of electrical resistance, transfer area requirements, and energy consumption.

Metathesis Reactions Using Ionic Membranes, G. P. Monet, Du Pont, Wilmington, Del.

Metathesis reactions can be carried out by electrodialysis using ionic membranes. Experimental techniques for measuring the potential drop across a unit cell and for measuring the selectivity and resistance of a single ionic membrane.

Ultra-filtration of Salt Solutions Through Ion Exchange Membranes, J. G. McKelvey, Jr., K. S. Spiegler, and M.R.J. Wyllie, Gulf Research & Development Co., Pittsburgh, Pa.

Ion-exchange resin membranes were used in the ultra-filtration of sodium chloride solutions of various concentrations. The experiments were conducted in a special ultra filter.

LOW TEMPERATURE PROCESSING (Simultaneous with Labor Costs and Membrane Sessions), Clyde McKinley, Air Products, Inc., Allentown, Pa., chairman.

Heterogeneous Phase Equilibrium of the Methane-Hydrogen Sulfide System, J. P. Kohn, Univ. of Notre Dame, Notre Dame, Ind., and F. Kurata, Univ. of Kansas, Lawrence, Kan.

Experimental methane-hydrogen sulfide data, and additional data on the methane-carbon dioxide system, are used in projecting processes for the separation of hydrogen sulfide and carbon dioxide from natural gas.

Equipment for Determination of Liquid Viscosities of Normally Gaseous Hydrocarbons at Low Temperatures and High Pressures, G. W. Swift, J. A. Christy, A. A. Heckes, and F. Kurata, Univ. of Kansas, Lawrence, Kan.

An apparatus for the determination of the viscosity of liquefied hydrocarbon gases, designed to obtain data over a temperature range of 100° C. to —185° C.; a pressure range of 29 in. Hg vacuum to 1200 lb./sq.in gauge; a viscosity range of 0.01 centipoise to 2.0 centipoise. Data with less than 2% error are anticipated.

Preliminary Design Studies of Low Temperature Refrigeration Plants, Cycle Studies and Component Performance Requirements, D. Aronson, Worthington Corp., Harrison, N. J.

Ultra-low temperature refrigeration plants of industrial size, such as those for liquefaction of hydrogen at —420° F., call for so much power per ton of product that the efficiency of every phase of the system must be carefully evaluated. Here is a method of

(Continued on page 112)

PERMUTIT® presents the

VALVELESS FILTER

Completely Automatic Gravity Filter Costs Less than Manual Unit

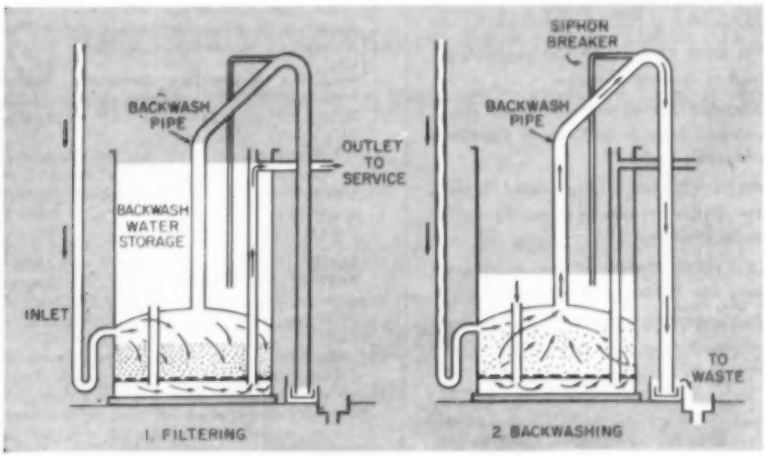
Uses no valves, no pumps, no flow controllers

Here's an entirely new concept in water filters for cities, factories and power stations: a filter that *eliminates* operation and maintenance expense . . . yet costs *less* than a conventional manually-operated gravity filter of the same size.

The Permutit Valveless Filter can be used wherever gravity flow is feasible. Units are now in operation providing both plant process and drinking water.

FOOLPROOF OPERATION

The Valveless Filter thinks for itself. It starts backwashing at a predetermined head loss, rinses and returns to service automatically . . . and as efficiently as an expertly operated manual filter. It assures uniform, high quality effluent because it eliminates "human error." It cannot be forced. It cannot backwash or rinse too soon or too late, too fast or too slow, too much or too little. It cannot develop a negative head and thus eliminates the chief cause of mudballs, channelling, upset beds. The absence of gravel eliminates another cause of upset beds. Backwash or rinse water cannot be accidentally run to service.



HOW IT WORKS

Filtering. Water enters at left, flows through sand, strainers and false bottom up effluent duct to service. As head loss increases during run, water rises in backwash pipe. At maximum headloss, water spills into downward section of backwash pipe and starts backwash (siphon) action.

Backwashing. Siphon draws water from storage down through ducts, up through strainers and sand to expand and wash bed, then to waste. At low storage level, air enters siphon breaker to stop backwash. Flow reverses and filtered (rinse) water flows into storage until full. All flow then goes to service.



PROVEN PERFORMANCE

Photo shows two Valveless Filters in a large industrial plant. (Shut-off valve at left is used only to take front filter out of service.)

LOW INSTALLATION AND EXPANSION COST

Filters up to 10 ft. diameter are shipped set up. Piping is simple. Future filters are easy to add since they require no additional backwash water storage or pump capacity. Filters use minimum floor space.

FREE BULLETIN

New bulletin, "The Permutit Valveless Filter," includes details, drawings, operating conditions, capacities. Address: The Permutit Company, Dept. CEP-7, 330 W. 42nd St., New York 36, N. Y. or Permutit Company of Canada Ltd., Toronto 1, Ont.

PERMUTIT®

rhymes with "computo it"

Water Conditioning

Ion Exchange • Industrial Waste Treatment

FACTORY MUTUAL APPROVED FOR THE ULTIMATE IN SAFETY

NEW

CHEMICAL FAUCET FOR FLAMMABLE AND CORROSIVE FLUIDS

Kel-F† SEALS



FUME TIGHT STAINLESS STEEL* FAUCET OVERCOMES SEIZURE PROBLEMS

Here is a faucet designed for minimum maintenance and the ultimate in safety for dispensing solvents, essential oils, chlorine-free bleaches, oxidizing agents, caustic solutions and many acids. They are in use in individual and central dispensing systems in laboratory, production and liquid storage areas throughout the chemical process industries.



Liquid dispensing at an Eastman Kodak storage area. More than 200 solvent storage drums are equipped with Economy chemiral faucets.

LOOK AT THESE FEATURES:

- NO AFTER DRIP — Kel-F "O" ring seals are inert to chemical exposure.
- DESIGNED FOR SAFETY — Anti-flash screen prevents flame propagation in dispensing flammable liquids.
- EASILY CLEANED — Disassembled in minutes, the faucet can be chemically and/or steam sterilized.
- LOW MAINTENANCE — Corrosion resistance with few moving parts assures long life.
- FACTORY MUTUAL APPROVED — Your assurance of quality construction and safe operation.

Write for complete information including detailed test report by Factory Mutual Laboratories.

* Also available in chrome-plated brass † M. W. Kellogg trademark for fluorocarbon resin

ECO ENGINEERING DIVISION

economy FAUCET CO.

12 NEW YORK AVE.
NEWARK 1, NEW JERSEY

BALTIMORE PROGRAM

(Continued from page 110)

predicting plant performance by establishing a set of efficiency terms by which the actual performance can be compared with an ideal performance.

High Capacity, Low Temperature, Halocarbon Cascade Refrigeration System, J. R. Harnish and N. E. Hopkins, York Division, Borg-Warner Corp., York, Pa.

Complete, detailed analysis of a refrigeration system built to provide cooling requirements for the Propeller Hub Altitude Test Facility at Wright-Patterson Air Force Base, Dayton, Ohio.

WEDNESDAY, SEPTEMBER 18

JET PROPULSION—PART II, PROJECT VANGUARD, C. J. Marsel, chairman.

Rocket Propulsion Systems of the Satellite Launching Vehicle, J. E. Burghardt, The Martin Co., Baltimore, Md.

Brief historical background of Project Vanguard, preliminary design considerations for the vehicle, including the number of stages, types of trajectory, liquid vs. solid propellants, and efforts to use "off the shelf" rocket propulsion systems. Present status of the design is described.

Turbine and Rocket Fuels—Present and Future, D. N. Harris and W. S. Little, Jr., Shell Oil Co., New York, N. Y.

A comprehensive review of current petroleum fuel specifications for turbine and rocket powered systems which predicts the areas which may require changes for future high performance applications, gives an engineering evaluation of a fuel's performance, discusses the problem of thermal stability. Fuels for the Vanguard and Navaho missiles are used as examples.

Preparation and Properties of Unsymmetrical Dimethylhydrazine, W. G. Strunk, Westvaco Division, Food Machinery & Chemical Corp., South Charleston, W. Va.

The use, desirability, performance, and characteristics of unsymmetrical dimethylhydrazine as a rocket fuel.

Processing Rubber-Base Composite Rocket Propellant, C. F. Dougherty, Rocket Fuels Division, Phillips Petroleum Co., Bartlesville, Okla.

The chemical engineer has an educational background applicable to the solution of problems encountered in the processing of a rubber-base composite rocket propellant. Process steps are analyzed.

SAFETY IN AIR AND AMMONIA PLANTS—PART II, AIR PLANT SAFETY, (Simultaneous with Jet Propulsion and Drying Sessions), N. H. Walton, Atlantic Refining Co., Philadelphia, Pa.

Agenda for the open group discussion is: 1) Air intake location; 2) Permissable levels of hydrocarbons other than acetylene; 3) Should methane cause concern; 4) Acetylene, ozone, oxides of nitrogen; 5) Analysis by instrumentation; 6) Lubrication; and 7) Removal of particulate matter at intake.

DRYING, (Simultaneous with Jet Propulsion and Air Plant Safety Sessions), R. E. Peck, III. Inst. of Tech., Chicago, Ill., chairman.

Sublimation From Sharp-Edged Cylinders in Axisymmetric Flow, W. J. Christian, Armour Research Foundation, Ill. Inst. of Tech., Chicago, Ill. and S. P. Kezios, Ill. Inst. of Tech., Chicago, Ill.

(Continued on page 114)



SAVE ON TOWER MAINTENANCE

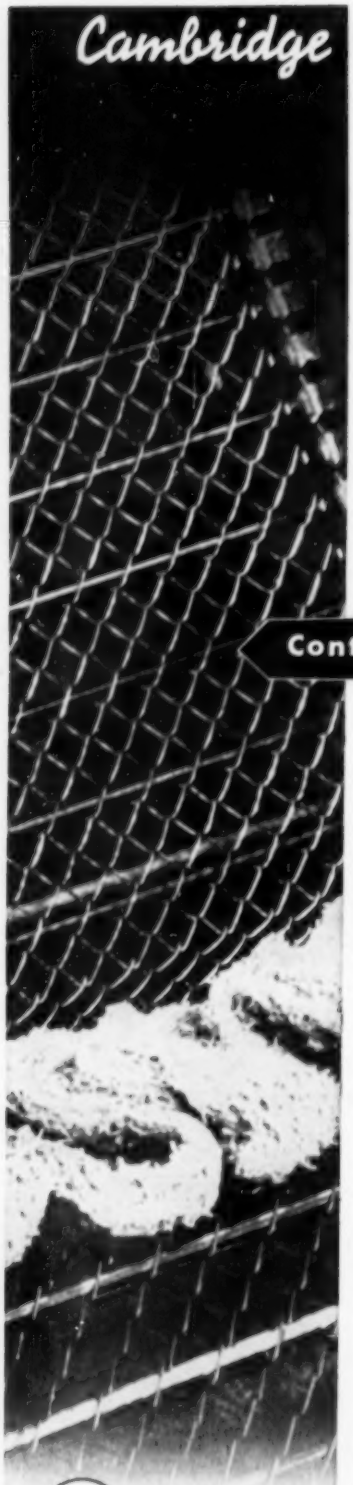
PACK WITH LAPP PORCELAIN RASCHIG RINGS

Lapp raschig rings are smooth, completely vitrified, strictly non-porous and iron free. They are chemically inert to acids of all concentrations (except hydrofluoric); there can be no crumbling from capillary pressures nor absorption of liquids to contaminate later processing. This combination of characteristics assures an indefinite life chemically. Physically, Lapp raschig rings are tougher against damage from handling and tower operation than other ceramic rings or other packing shapes.

Lapp customers report longer continuous service and greater purity of product from their Lapp packed towers . . . with greatly reduced maintenance costs.

WRITE for our bulletin describing the characteristics of Lapp Chemical Porcelain. See how you can save with a trouble-free system of Lapp Porcelain. Lapp Insulator Co., Inc., Process Equipment Division, 432 Chestnut St., Le Roy, New York.

Lapp
CHEMICAL
PORCELAIN



WOVEN WIRE BELTS give you continuous processing to lower costs, increase uniformity

You can eliminate time-consuming and expensive batch handling by using woven wire conveyor belts to combine movement with processing. Slab, sheet, granular or pelletized materials can be rapidly and uniformly washed, dried, heated or cooled in one smooth, continuous operation. In packaging, filling, weighing or sealing operations, uninterrupted movement on wire belts helps increase production and cut labor costs by eliminating manual handling. EXAMPLE:

Continuous Drying

MOVING BELTS carry fibres through drying oven in steady, continuous operation.

OPEN MESH allows free circulation of heat or process atmospheres around all parts of product. In washing or chemical treating operations, open mesh also permits quick drainage of process solution, uniform treatment of material. Spilled material drops through for easy salvage.

ALL METAL BELT easily withstands temperatures from sub-zero up to 2100° F.; rust-proof alloys can be used for operation in corrosive conditions.

WOVEN WIRE CONSTRUCTION provides extra strength, extra long life. There are no seams, lacers or fasteners to break or wear. Special raised edges or surface attachments are available to hold even smallest parts in position on the belt during flat or inclined movement.

Cambridge Woven Wire Conveyor Belts are made in any size, mesh or weave, from any metal or alloy, and can be used under a wide range of conditions . . . hot or cold . . . wet or dry. Call your Cambridge Field Engineer to discuss how you can cut costs with continuous processing on woven wire conveyor belts. Look for his telephone number under "Belting, Mechanical" in the *Yellow Pages*. Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

WIRE CLOTH | WOVEN WIRE CONVEYOR BELTS | WIRE CLOTH FABRICATIONS

Department 1, Cambridge 7, Maryland



OFFICES IN PRINCIPAL INDUSTRIAL CITIES

BALTIMORE PROGRAM

(Continued from page 112)

An experimental investigation of the mass transfer by sublimation from the outer surfaces of hollow naphthalene cylinders in parallel air streams at velocities between 20 and 120 ft./sec.

Heat Transfer in Spray Dryers, J. P. Tourtellotte, Swenson Evaporator Co., Harvey, Ill., and R. E. Peck, Ill. Inst. of Tech., Chicago, Ill.

The development of a rational design procedure for spray drying using data correlated from existing commercial installations. Two types and various sizes of spray dryers were used.

Development of an Improved Heat Transfer System for Batch Freeze-Drying, I. M. Abelow, Chemical Corps, Fort Detrick, Md., and E. W. Flosdorf, F. J. Stokes Machine Co., N. Philadelphia, Pa.

The collection of data leading toward the design of an improved heat transfer system for batch freeze-drying. Results demonstrate practical applications for obtaining shorter cycles and more uniform temperature conditions for bulk batch type drying operations.

Evaporation from Drops Containing Dissolved Solids, D. N. Charlesworth, Atomic Energy of Canada, Ltd., Chalk River, Can., and W. R. Marshall, Jr., Univ. of Wisc., Madison, Wisc.

Experimental study of the evaporation from single drops containing solids. A theory is advanced for predicting the formation of a solid phase in drying a droplet containing a dissolved solid and a tentative proposal is made for the application of the results to spray dryer performance.

Relation Between Dry Particle and Original Wet Spray in Spray Drying, E. J. Crosby, Du Pont, Wilmington, Del., and W. R. Marshall, Jr., Univ. of Wisc., Madison, Wisc.

A spray drying study of sodium sulfate, clay, and coffee extract with a comparison made between the particle size of the dry particle and the original spray droplet.

Vortex Flow Patterns in Spray Drying, W. R. Thomas, Du Pont, Parlin, N. J., and W. R. Marshall, Jr., Univ. of Wisc., Madison, Wisc.

Measurements of the velocity components of air flowing in vortex motion through a transparent plastic spray dryer. Tangential velocities and axial and radial velocities were measured.

GENERAL PAPERS—II, J. R. Mecredy, Davison Chemical Corp., Baltimore, Md., chairman.

Gas Absorption Accompanied by a Liquid Phase Chemical Reaction, E. R. Gilliland, R. F. Baddour, and P. L. T. Brian, MIT, Cambridge Mass.

Rate of absorption of chlorine from chlorine-nitrogen mixtures into solutions of ferrous chloride in 0.203 N aqueous hydrochloric acid in a short wetted-wall column.

Large Scale Continuous Production of Ammonium Perchlorate, J. C. Schumacher and D. R. Stern, American Potash & Chemical Corp., Los Angeles, Calif.

Factors leading to the design of a large scale continuous production of ammonium perchlorate including data on solubility, safety, hazards, materials of construction, process flow, instrumentation, and operating variables.

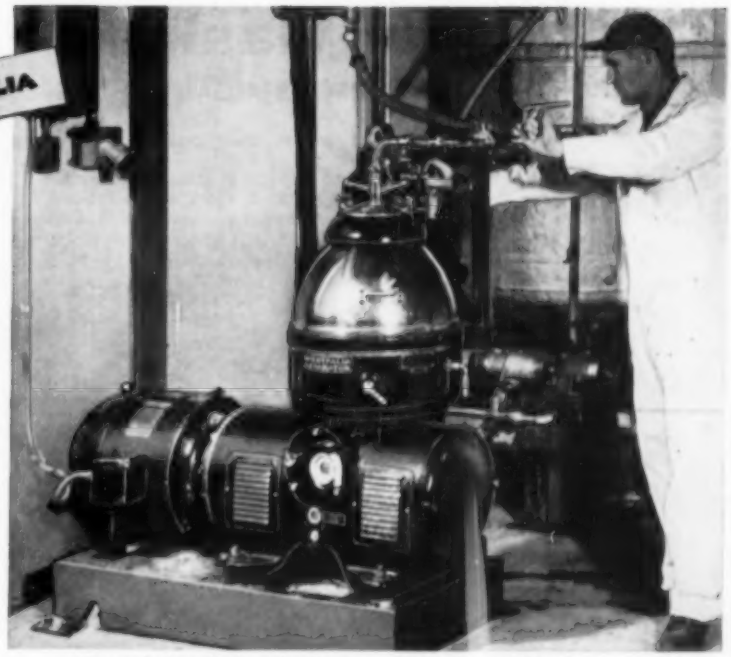
Mixing of Fluids Flowing Through Beds of Packed Solids, E. A. Ebach and R. R. White, Univ. of Mich., Ann Arbor, Mich.

The axial mixing of dyed water using the pulse function and frequency response tech-

(Continued on page 116)

The Trend is to WESTFALIA

Why Do Process Engineers in the Flavoring Extract and Essential Oil Industry Select WESTFALIA KG Clarifiers?



Recently installed at the Boonton, N. J. plant of Norda Essential Oil & Chemical Company, this WESTFALIA KG-4006 clarifies emulsified flavoring extracts prior to spray drying. Norda also uses a dolly-mounted WESTFALIA model KG-2006 to clarify depectinized fruits.

More and more, plant managers and process engineers in the flavoring extract and essential oil industry are turning to WESTFALIA KG clarifiers as a vital part of their expansion and modernization programs.

Here are a few of the progressive organizations which are realizing new economies and greatly increased output with the WESTFALIA KG clarifiers, while assuring their customers of products with unsurpassed quality: POLAK & SCHWARZ, INC., Teterboro, N. J., producers of true fruit extracts and vanilla concentrates for the beverage, ice cream and food industries; MAGNUS MABEE & REYNARD, INC., New York, N. Y., internationally famous in the field of essential oils, concentrated flavors and basic perfume materials; NORDA ESSENTIAL OIL & CHEMICAL COMPANY, Boonton, N. J., manufacturers of fruit flavors, concentrates, extracts for the exacting requirements of the food and beverage industries.

Why the widespread trend toward the WESTFALIA KG clarifier?

- First, constant high efficiency – the efficiency of the WESTFALIA clarifier is just as high at the end of the cycle as it is when the bowl is empty.
- Second, the extremely large solids-holding capacity of the unique multi-chamber bowl allows the operator to run the machine for longer periods of time before bowl cleaning is necessary.
- Third, the KG removes *only* undesirable solids, and retains full aroma and taste of the product.

The essential oil and flavoring extract industry is only *one* of the many fields where the KG clarifier is increasing efficiency and economy. The WESTFALIA KG is now being used more and more widely in the general chemical industries, in production of pharmaceutical and biological products, and in a wide range of food and beverage industries.

Won't you let us help you with YOUR liquid clarification or solids recovery problem?

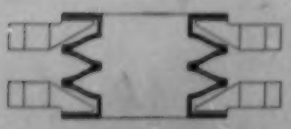
*Write for your free copy of Bulletin No. 2007

WESTFALIA SEPARATOR CENTRICO INCORPORATED

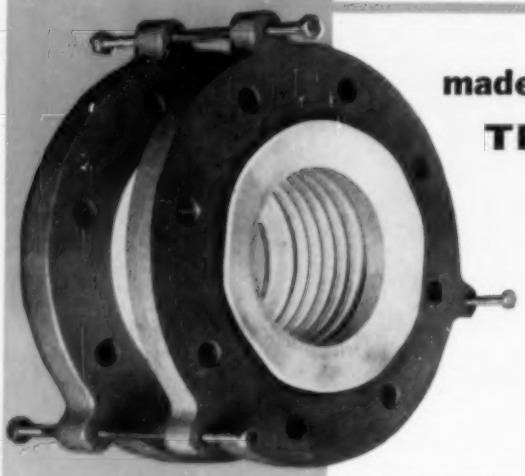
75 West Forest Avenue, Englewood, N. J. * Phone LOwell 9-0755

Chemiseal Gaskets

AND ACCESSORIES FOR CHEMICAL PIPING



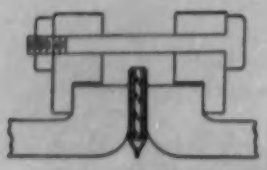
Chemical Expansion Joints and Flexible Couplings absorb shock and vibration, thermal expansion and contraction. Correct misalignment. Connect unlike piping ends and nozzles. Companion Products to the famous Garlock Rubber Expansion Joints. Catalog No. AD-137.



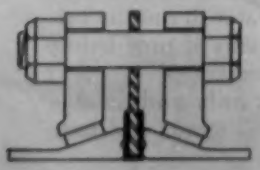
made of duPont TEFLON

impervious to

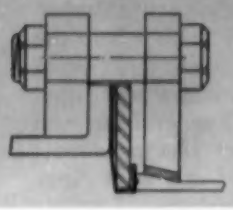
- **ACIDS**
- **ALKALIES**
- **SOLVENTS**



Chemiseal Jacketed Gaskets. Compressed asbestos sandwiched between woven asbestos and contained in Type 1 Teflon envelope. Ideal for sealing glass-lined steel connections. One of many types utilizing filler constructions ranging from soft woven asbestos to corrugated stainless steel, depending on service requirements. Catalog No. AD-154.



Chemiseal Jacketed Gaskets. Standard for Corning conical flanges. Neoprene filler. Type 2 Teflon envelope with flat surface fitting flush with pipe I.D., permitting free flow of medium. Catalog No. AD-154.



Chemiseal Reducers. A steel bearing ring provides rigidity. Resilient core assures safe seal at low bolt loads. Teflon Jacket protects and contains easy-to-handle single unit. Catalog No. AD-154.

United States Gasket Company
Camden 1, New Jersey

United States Gasket *Plastics Division*
OF THE GARLOCK PACKING COMPANY

BALTIMORE PROGRAM

(Continued from page 114)

niques for flow through beds of spheres, Raschig rings, Berl saddles, and Intalox saddles.

Wall Effect for the Fall of Single Drops, J. R. Strom and R. C. Kintner, Ill. Inst. of Tech., Chicago, Ill.

Measurements of the rate of fall of drops of five organic liquids through an aqueous phase contained in eight vertical cylinders of various diameters.

SAFETY IN AIR AND AMMONIA PLANTS—PART III, AIR PLANT SAFETY, (Simultaneous with General Papers—II Session) N. H. Walton, chairman.

Agenda for this third open discussion session: 1) silica gel adsorbers and prefilters; 2) frequency and method of cleanouts; 3) metal inspection; 4) shutdown procedures; 5) desirability of industry sponsored project on catalytic oxidation of air intake.

FUTURE MEETINGS

■ **STATE COLLEGE, PA.**

(Continued from page 102)

• Tuesday Morning, Aug. 13, Session 5: Experimental Velocity and Temperature Profiles for Air in Turbulent Pipe Flow, C. A. Sleicher, Jr., Shell Development Co., Emeryville, Calif.; Heat Transfer and Pressure Drop in Odd-Shaped Annuli, C. Johannes & R. R. Kraybill, Univ. of Rochester; Momentum and Mass Transfer by Eddy Diffusion in a Wetted-Wall Channel, A. M. Dhanak, Gen. Elec.

• Tuesday Afternoon, Aug. 13, Session 6: Combined Free and Forced Convection in a Constant Temperature Vertical Tube, W. B. Harrison, W. C. Boteler, & T. W. Jackson, Georgia Tech; Gas Friction and Heat Transfer in Ducted Flows, S. V. Manson, Curtiss-Wright, Clifton, N. J.; Heat Transfer to Super-Critical Water, N. L. Dickinson & C. P. Welch, Babcock and Wilcox, Alliance, Ohio; Convective Heat Transfer from High Temperature Air Inside a Tube, H. E. Zellnick & S. W. Churchill, Univ. of Mich.

Tuesday evening, Aug. 13: Banquet in honor of Professor W. H. McAdams, one of the great men of the chemical engineering profession, who is retiring this year at M.I.T.

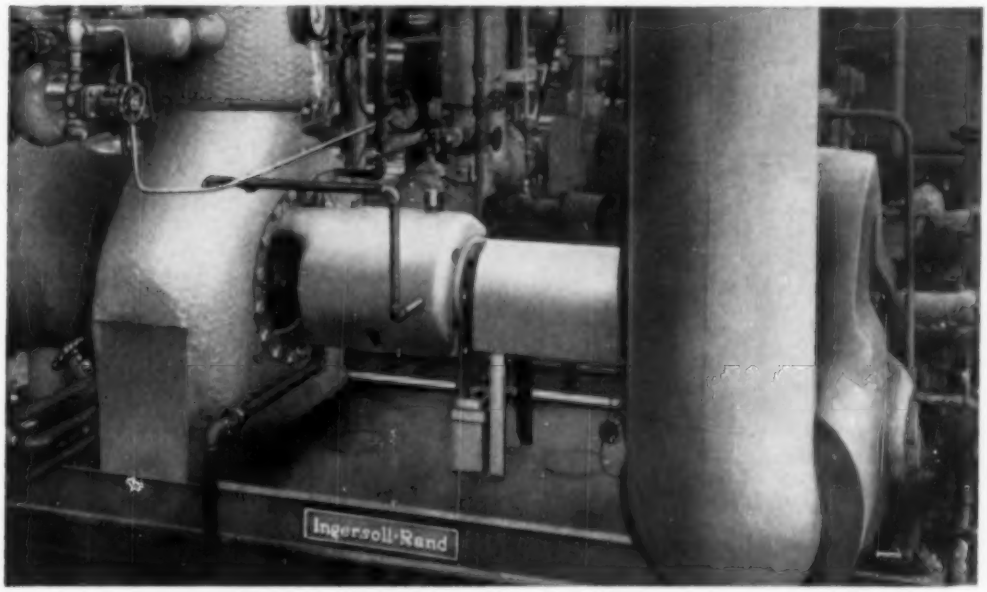
• Wednesday Morning, Aug. 14, Session 7: Modes of Adiabatic and Diabatic Fluid Flow in an Annulus with an Inner Rotating Cylinder, J. Kaye & E. C. Elgar, M.I.T.; Heat Transfer in Internal Combustion Engines, C. F. Taylor & T. Y. Toong, M.I.T.; Heat Transfer in Thin Film, Centrifugal Processing Units, A. R. Gudheim, Kontro Co., Petersham, Mass.

• Wednesday Morning, Aug. 14, Session 8: On the Stability of Boiling Heat Transfer, N. Zuber, Univ. of Calif.; Bubble Growth Rates in Boiling, Peter Griffith, M.I.T.; Correlation of Nucleate Boiling Burnout Data, Peter Griffith, M.I.T.; Film Boiling from a Vertical Tube, Y. Y. Hsu & J. W. Westwater, Univ. of Illinois.

• Wednesday Afternoon, Aug. 14, Session 9: Wetting Effects on Boiling Heat Transfer; The Copper-Stearic Acid System, W. B. Harrison & Z. Levine, Georgia Tech; Experimental and Analytical Study of Two-Phase Two-Component Flow in an Ejector with Condensation, J. Kaye & M. A. Rivas, Jr., M.I.T.;

(Continued on page 124)

THIS INGERSOLL-RAND CHEMICAL PUMP MUST STAY ON THE JOB

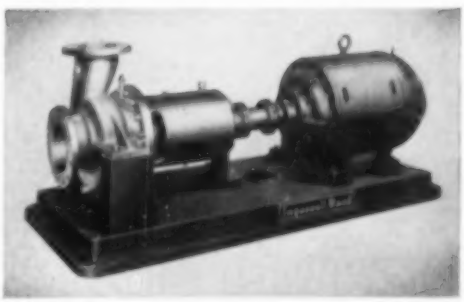


- **2 years of continuous operation**
- **Not a moment's down-time**
- **No spare pump**

This Ingersoll-Rand chemical pump is a key pump in the urea process at the Grace Chemical Company's plant in Woodstock, Tennessee. Here, the process is entirely dependent upon the pump. On stripper recirculating service, it is handling 4600 gpm of urea solution and oil at a temperature of 246°F, total head 117 ft. To withstand corrosion by the liquid handled, the pump parts are made of corrosion-resistant stainless steel.

In 2 years of continuous operation, without a spare, this pump has never been down for maintenance. Here is proven dependability in "round the clock" service.

If you are faced with a pumping problem, Ingersoll-Rand is ready to help you solve it. I-R manufactures a complete line of single and multi-stage centrifugal pumps in both horizontal and vertical designs. For further information just call or write your nearest I-R branch office.

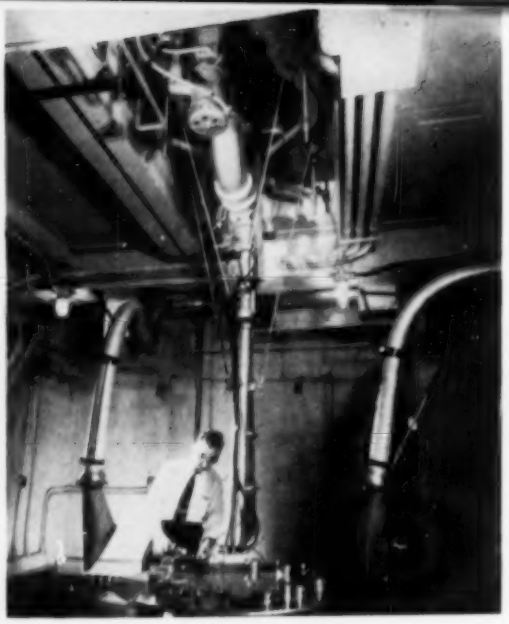


View of class CSFL pump of the same design as shown with lagging in the installation view above. Available in 6, 8 and 10-inch sizes, they are designed for handling large capacities of hot or cold liquids at temperatures to 800°F.

Ingersoll-Rand

10-614 11 Broadway, New York 4, N. Y.

CONDENSERS • PUMPS • GAS & DIESEL ENGINES • COMPRESSORS • AIR & ELECTRIC TOOLS • TURBO BLOWERS • ROCK DRILLS



Business end of Gulf's new "atom smasher" which will probe the application of nuclear energy to petroleum production, refining.

Also: see first pictures of U. of Mich. synthesis pilot plant on page 141.

New Facilities, Extensive Study Lead Way to

RADIATION PROCESSING OF PETROLEUM

Major new radiation laboratories of Gulf and Texaco draw attention to the growing importance being given radiation processing techniques by refiners, presage progress in the application of nuclear radiation to chemical processing.

While no petroleum company has yet built a commercial plant for radiation-promoted processing, nearly all are committed to full-scale research, engineering analysis, and development work toward the early utilization of this high-potential processing tool. In addition, many independent research groups, such as the University of Michigan's Phoenix Laboratory and Fission Products Laboratory (where chemical engineers H. A. Ohlgren and J. J. Martin are at work) are being engaged under contract by refiners to carry on additional studies.

Latest Entries

Gulf Oil's new multimillion dollar A. W. Mellon Nuclear Science Laboratory is now in full operation; Texaco's fully-equipped nuclear radiation laboratory, which went into construction in June, is to be completed early next year.

Key to commercial radiation processing, according to W. A. Wilson, Standard Oil (Indiana), in a talk before an NICB meeting at the recent Nuclear Congress, is radiation efficiency.* The type of radiation seems to have little effect on reaction efficiency. Work is being carried out with gamma rays, *x*-rays, beta rays, high-energy electrons, alpha particles, and neutrons, and except when neutron capture results in induced radioactivity, no major differences are seen within ranges of energies of particles found in the fission reactions now used.

The New Laboratories

Gulf's lab at Harmarville, Pa., will be equipped with a 3-million volt Van de Graaff particle accelerator for its main studies, while Texaco's lab will have three different radiation sources: a 3-million volt Van de Graaff, a 6-million volt linear accelerator (first in the industry), and a 35,000 curie cobalt-60 source of gamma radiation.

Some of the work in progress at Gulf is the irradiation of catalysts to improve their efficiency, and the possibility of substituting radiation for high temperatures in an attempt to produce chemical and petroleum products heretofore beyond the bounds of possibility because too great heat would destroy the material whereas radiation may achieve the same effect without harming the material.

A major step forward is Gulf's production of hexamethylethane, the highest quality gasoline component, from refinery gases by irradiation. At present the cost is prohibitive, but Gulf is certain that the achievement illustrates the vast possibilities of radiation processing.

Fig. 1.—Radiation Sources in the Oil Industry

Electron machines	Gamma sources	Nuclear reactors
Atlantic	California	Socony
Gulf	Cities Service	
Humble	Continental	
Shell	Esso	
Socony	Sinclair	
Texas	Sun	
California	Texas	

Radiation Reactions—The Mechanism

In his analysis before NICB Wilson showed that radiation-promoted reactions have different efficiencies because they are chain reactions and the number of molecules converted depends on both the initiation step and the chain length.

In most processes, radiation provides free radicals for the initiation step, and chain growth or transfer takes place according to the environment. In high-efficiency reactions, chain growth or transfer is extremely efficient with many reactant molecules converted per free radical formed.

In certain solid or gas reactions in which no ionization takes place, pronounced effects have been measured but there is little understanding of the mechanisms involved, according to Ohlgren, who heads up one of the groups studying radiation processing at the University of Michigan. However, Eyring, at Utah Univ., has done work in forming kinetic equations for these types of reactions.

In addition, solid-state crystal lattice changes effected by radiation are also difficult to explain by free-radical formation.

Among reactions the industry has already found to have high efficiency are: chlorination of aromatics, polym-

(*Continued on page* 120)

* In chemical processing by radiation, efficiency is defined in terms of G-value, i.e. the number of molecules converted per 100 volts of energy absorbed. Actually, G-value can only be measured indirectly by measuring the radiation dose going into the reaction and the radiation coming out, the difference being assumed to have been absorbed. Work on direct measurement is in progress.

76 years of KOVEN fabricating *Experience* built into every job



Conical bottom storage bins. Field erected. Made in all metals

30' Diameter Head for Special Reactor Vessel

X-RAY INSPECTION FOR QUALITY CONTROL

KOVEN equipment in all metals and alloys includes: High pressure vessels built to A.S.M.E., A.P.I. Codes; extractors; mixers; stills; kettles; tanks; stacks; breechings; hot transfer lines; large diameter fabricated piping and plate exhaust ducts; shop and field erected storage tanks; high vacuum testing.

Call or write for a consultation with a trained KOVEN representative, and send for Bulletin #550.

Members of Steel Plate Fabricators Association

SPECIALISTS IN INTRICATE FABRICATION USING:

STAINLESS STEEL

ALUMINUM • MONEL

NICKEL • INCONEL

ALL CLAD MATERIALS

NICKEL PLATED STEEL

Fabrication to all A.S.M.E. Codes

See Sweet's Catalog File and Chemical Engineering File

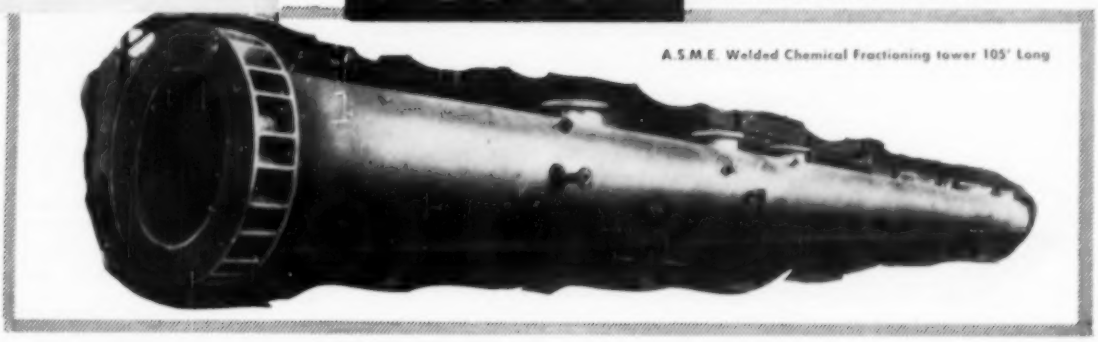


Jacketed mixing kettle made of steel

Koven

KOVEN FABRICATORS, INC.
91 E. Dickerson St., Dover, New Jersey

Telephone: FOxcroft 6-0400
PLANTS: JERSEY CITY, DOVER, TRENTON, N. J.



A.S.M.E. Welded Chemical Fractioning tower 105' Long

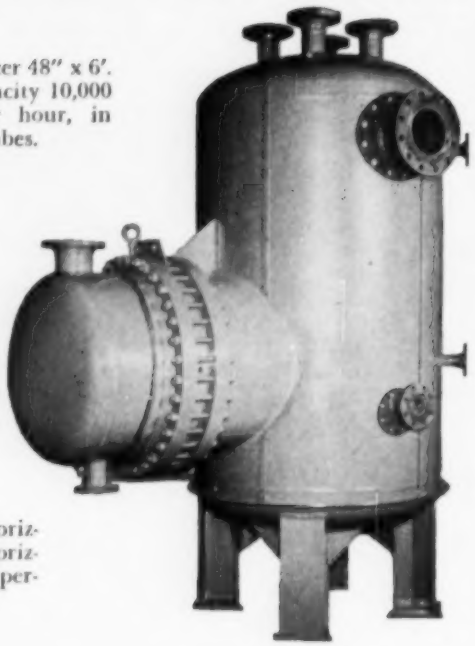
Chemical Engineers Appreciate

Armstrong's

Better Approach to

VAPORIZING PROBLEMS

Vertical Steel Vaporizer 48" x 6'. Reboiler Type. Capacity 10,000 gals. of butane per hour, in shell; steam inside tubes.



Built as straight vaporizers or combined vaporizers with built-in superheating sections.

For Ammonia can be furnished with tube bundle of SS 304, or SS 304L, to assure freedom from corrosion.

We make also two basic types of vertical bayonet vaporizer. Type One—general purpose—for field use in vaporizing propane or butane. Type Two—heavy duty, using heavy TEMA R type of construction for refinery or chemical plant construction.

Heavy duty type built specially to suit the individual case, rugged refinery construction, well suited to both Chlorine and Ammonia.

We Invite
Your Inquiries on
Vaporizing Problems

RICHARD M. ARMSTRONG CO.
BOX 188
WEST CHESTER PENNA.

RADIATION PROCESSING

(*Continued from page* 118)

erization of ethylene or styrene to solids, copolymerization of butadiene and styrene or olefins and sulfur dioxide, and oxidation of ethylene to acids and aldehydes. Many vinyl polymerizations are also of high efficiency.

Moderate efficiency reactions already studied are: polymerization of propylene, butadiene, acetylene, and probably most other alkenes. Among low-efficiency reactions are: most paraffin and aromatic conversions—including cracking, alkylation, and condensation.

There are few experiments reported to date that show the combined effects of radiation and catalysts. (The group under Ohlgren at Michigan is making important strides in this direction in the course of their more "chemical engineering" type studies into the effect of radiation in combination with more normal processing techniques. Announcement of results of this work is likely as soon as patent matters are settled.) Wilson mentions three such reactions: the deleterious effect of gamma radiation on ZnO hydrogenation catalysts, the enhancement of isomerization activity of a silica catalyst by neutron irradiation, and the gamma ray irradiation of pure aluminas at dry-ice temperatures which make them temporarily active as catalysts for hydrogen-deuterium exchange. One of the basic studies at Michigan is the problem of catalyst selectivity, i.e., the catalyst may be good for a certain end product thermally, but radiation can change the effect into an entirely different direction. It is clear, however, that there can be interaction between radiation and solid catalysts and much activity within the industry is involved in this field.

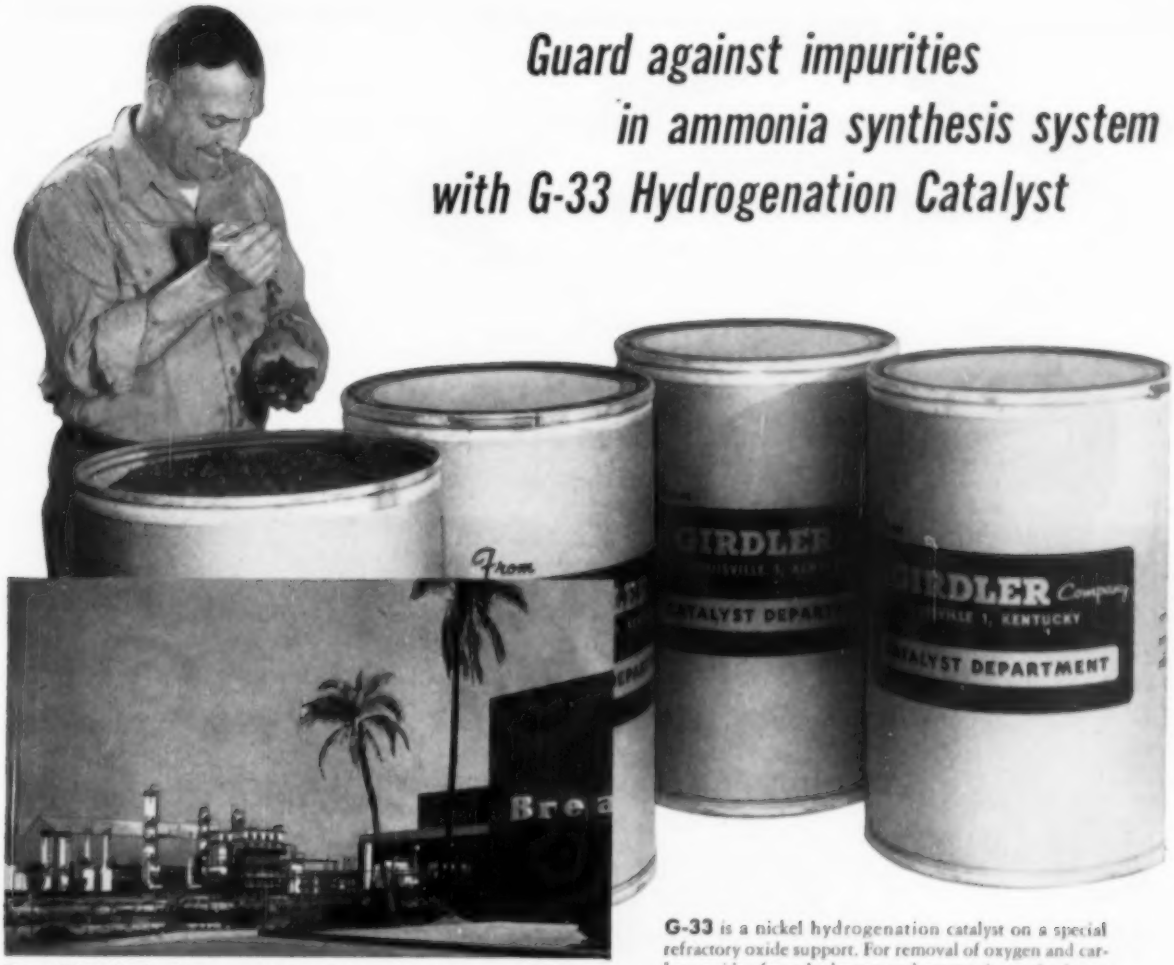
While high conversion with little energy absorption is important in radiation induced reactions, materials that undergo little conversion with the absorption of large amounts of energy also have valuable uses. These are in and around atomic power plants where radiation resistant hydrocarbons can be important, as, for example, neutron moderators, reactor coolants, and lubricants for moving parts.

Economics of Radiation Processing

The costs involved in radiation processing, Wilson explained, are functions of many factors—primarily the amount of energy needed and the cost of the radiant energy. The

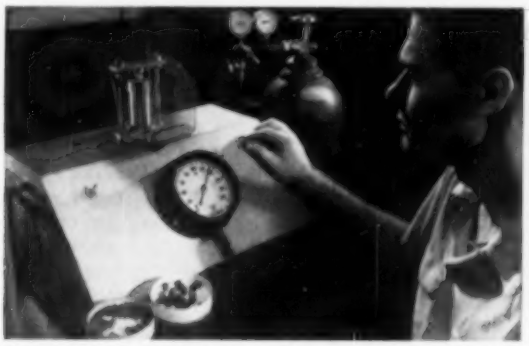
(*Continued on page* 122)

Guard against impurities in ammonia synthesis system with G-33 Hydrogenation Catalyst



Brea Chemicals, Inc., uses Girdler G-33 catalyst in the methanators to remove oxygen and carbon oxides in the feed gas to the ammonia synthesis system. This catalyst not only smooths out normal fluctuations in purity of the synthesis gas, but also protects the stream from abnormal concentrations of impurities which may result from upsets in the system.

G-33 is a nickel hydrogenation catalyst on a special refractory oxide support. For removal of oxygen and carbon oxides from hydrogen and ammonia synthesis gas streams where the catalyst may be subjected to *severe physical stress*. Also used for hydrogenation of organic compounds such as aldehydes, ketones and aromatics.



Physically rugged. G-33 catalyst must be able to perform under stresses induced by liquid or mixed phase operations. Girdler makes extensive analyses of physical properties to assure adequate strength. Write for bulletin on Girdler catalysts.



Want better performance? Girdler's continuing program of catalyst improvement, high standards of quality control, and experience in solving catalyst problems can help improve *your* processing.

CATALYST DEPARTMENT

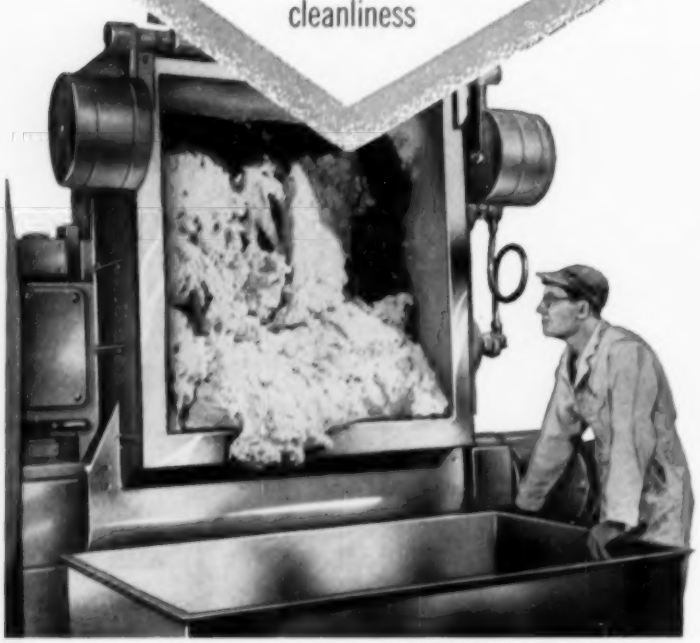
GIRDLER MANUFACTURES CATALYSTS FOR: HYDROGENATION • SYNTHESIS GASES AND HYDROGEN GENERATION • DESULFURIZATION • NEW CATALYTIC PROCESSES

The **GIRDLER** Company

A DIVISION OF NATIONAL CYLINDER GAS COMPANY

LOUISVILLE 1, KENTUCKY

for mixing
silicone rubber compounds
BAKER PERKINS mixers are chosen
for high production and
extreme
cleanliness



At the Dow Corning silicone plant in Midland, Michigan, some of the first pages in the history of silicone rubber were written. Today in Dow Corning's large, modern Silastic* building, Baker Perkins chemical mixers such as the one shown here, are steadily at work, busily filling the demand for this new product of chemical research.

Dow Corning engineers, with years of experience in silicones, invariably choose rugged, dependable B-P mixers because these machines get out a record volume of silicone rubber production with a minimum of lost time in cleaning and servicing. Dust-tight, these B-P mixers assure perfect product cleanliness.

All B-P mixers are constructed in iron, steel, or alloys suitable for the material to be handled. In addition, they can be built for vacuum operation, and are particularly suited to mixing and drying heat-sensitive materials that go through a wide range of physical states, such as from a liquid to a plastic, to a powder . . . in one continuous operation.

Call on your Baker Perkins Sales Engineer today. His long experience is yours for the asking.

*T.M. Dow Corning Silicone Rubber

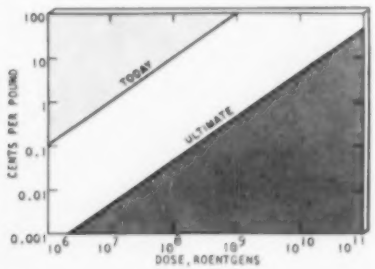
BAKER PERKINS INC. SAGINAW, MICHIGAN

346

RADIATION PROCESSING

(*Continued from page 120*)

amount of energy needed is inversely proportional to both efficiency and molecular weight of the reactant. The cost of radiant energy is not really known at present, but various estimates of all radiation sources have been made and the result is a cost of about $1.00/kw.-hr. The industry is certain that these costs will be much lower in the future, possibly less than one cent/kw.-hr. The rapid growth of commercial nuclear power will increase radiation sources, and much work is going on now to reduce the cost of processing these sources so that they can be economically used for application to chemical processing.



Cost in cents per pound of product as a function of radiation dose. Upper line shows today's range, lower the rock-bottom cost for the future.

In general, energy needed for complete conversion in a low efficiency—low molecular weight reaction is from one to 10 billion roentgens; for a moderate efficiency reaction it is one-tenth to one billion roentgens; and for a high efficiency reaction it is less than 100 million roentgens.

Today, 100 million roentgens would add about 10 cents/lb. to processing costs. In the future these prices could be as little as 1 per cent of today's costs.

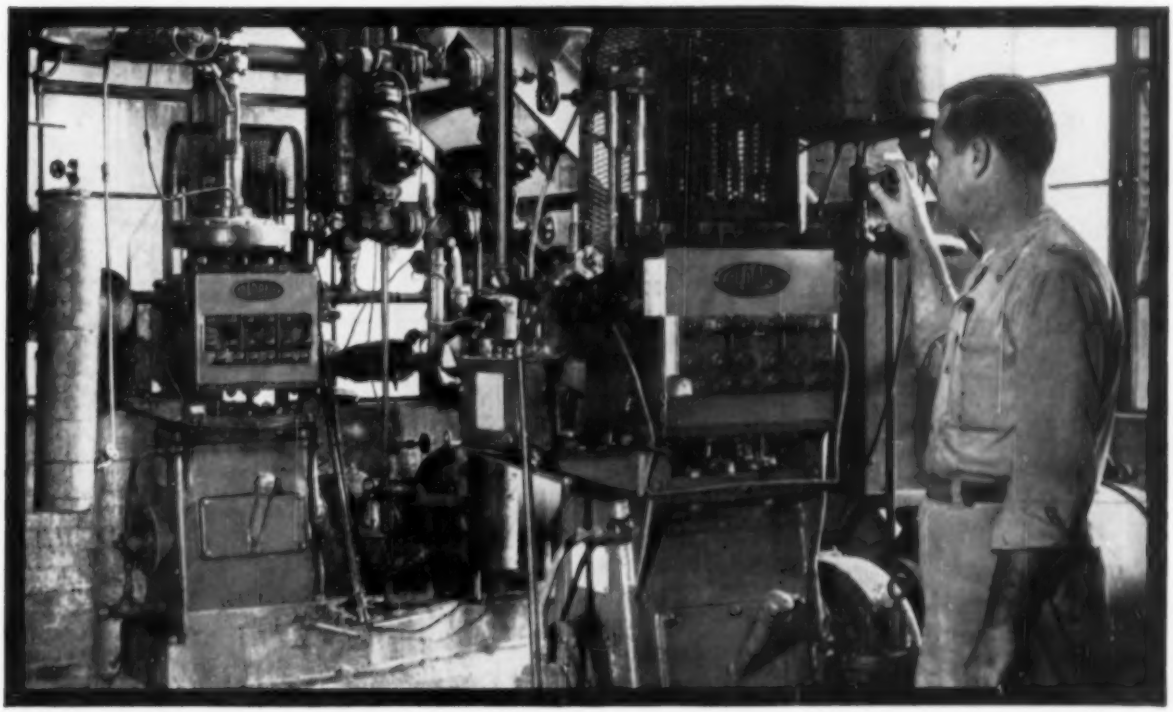
At today's radiation cost, reactions with G-values greater than 1,000 (high-efficiency) would cost pennies per pound. This price could be borne by many chemical products. Without doubt radiation will be used first on a commercial scale in processes of this magnitude of efficiency.

In all areas of radiation processing increases in efficiency of conversion would decrease the cost and most studies now being carried out are aimed at this goal. But economics are vital, and many processes, such as olefin reactions to form gasoline (of the type Gulf has successfully completed), although economic borderline cases now, are almost certain to be attractive to the engineer in the future.

EMERY INDUSTRIES LICKS TOUGH PROBLEM:

How to pump fatty acids 24 hours a day, 7 days a week, and cut maintenance costs!

Around-the-clock hydrolysis produces fatty acids from animal fats, tallow, palm, soybean, cottonseed and corn oils at Emery Industries plant in Cincinnati, Ohio. Pumps work on hot corrosive fatty materials 24 hours a day, seven days a week, and maintenance used to be a costly problem. Packings had to be replaced far too often. Valves needed frequent refacing. Wear of plungers was excessive.



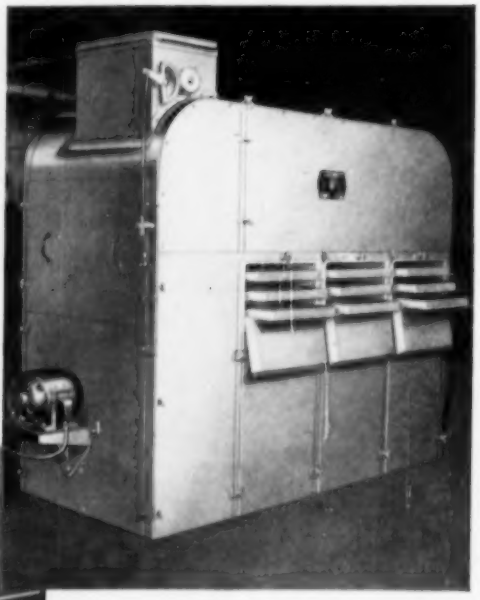
How Emery solved the puzzle: Looking for an answer to the problem of excessive downtime and maintenance, Emery conferred with several pump manufacturers. Aldrich was the only company to offer a pump better in both design and materials . . . the fluid end being of stainless steel. Original, ineffective pumps were immediately replaced with Aldrich Triplex Pumps.

Result: Two Aldrich Pumps have pumped raw materials on a continuous basis since 1948. Two more were installed for additional capacity in 1954. Maintenance costs have been reduced substantially. Downtime has decreased to a minimum. Operating efficiency is now at an all-time high and quality of processing has improved. We'll be glad to send you full information on Aldrich Pumps and their advantages to you. Simply write Aldrich Pump Company, 3 Gordon Street, Allentown, Pa.

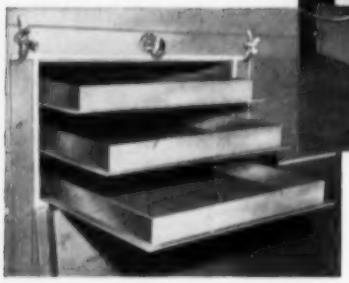
the toughest pumping problems go to ALDRICH

TRAY DRYING AT ITS BEST!

by SARGENT



9-tray Sargent Dryer for reclaimed rubber. Equipped with explosion-proof latch so that door in back simply opens should pressure build up within the dryer. Installation in large chemical plant.



Pilot Plant Sargent Tray Dryer — 3 trays, even circulation of air over and through all trays. Air flow may be adjusted to product needs easily and quickly. Installation in food plant.

There's a Tray Dryer by Sargent to do the job. From one tray to dozens; from small table or lab models to huge, multi-stacked, multi-tray jobs; from s-l-o-w drying cycles for sensitive or unstable materials to high-speed drying where "flash" methods are indicated.

All are of Sargent's famous dependably sturdy and trouble-free design and construction; completely automatic operation with simple changeover to manual for small test or research runs; fully instrumented; Guaranteed performance and complete product control; product protection with uniform quality results every charge. All are performance-proven with a wide variety of products — from abrasives to waste sludge.

A Sargent Dryer will do the job for *your* product — better, easier, at less cost. Want details? Just ask your nearest representative or write or phone us.

C. G. SARGENT'S SONS CORPORATION

Graniteville, SINCE 1852 Massachusetts

PHILADELPHIA 19 — F. E. Wasson, 519 Murdock Road
CINCINNATI 15 — A. L. Merrifield, 730 Brooks Avenue
CHARLOTTE, N.C. — W. S. Anderson, Carolina Specialty Co.
ATLANTA, GA. — J. R. Angel, Mortgage Guarantee Building
TORONTO 1, CAN. — Hugh Williams & Co., 27 Wellington St. East

FUTURE MEETINGS

(*Continued from page 116*)

Heat Transfer from Superheated Vapors to a Horizontal Tube, Garen Balekjian & D. L. Katz, Univ. of Mich.; Horizontal Condenser Theory 1: Mathematical Development of Tube Loading, D. Q. Kern, D. Q. Kern Associates, Cleveland, Ohio.

● Thursday Morning, Aug. 15, Session 10: Control of Flow Sensitivity by Mixing Headers, S. C. Hyman, A. R. Gruber, & Leon Joseph, Nuclear Development Corp. of America, White Plains, N. Y.; Heat Transfer in a Round Tube with Arbitrary Velocity Distribution, I. R. Whiteman, Univ. of Calif., Los Angeles, & W. B. Drake, Lockheed Aircraft Corp., Van Nuys, Calif.; Natural Convection Heat Transfer in Regions of Maximum Fluid Density, R. S. Schecter & H. S. Isbin, Univ. of Minn.

● Thursday Morning, Aug. 15, Session 11: Heat, Mass, and Momentum Transfer in Flow Through Porous Media, L. Green, Jr., Aerojet-General Corp., Azusa, Calif.; Heat Transfer Between Fluidized Solids Beds and Boundary Surfaces-Correlation of Data, L. Wender & G. T. Cooper, M. W. Kellogg Co., N. Y.

■ BOULDER, COL.

August 19-21, 1957. National Bureau of Standards offices. Cryogenic Engineering Conference.

For information contact K. D. Timmerhaus, Dept. of Chemical Engineering, Univ. of Col., Boulder, Col.

Program includes: **Cryogenic Process**—liquefaction cycles, purification of gases, distillation, fluid flow, catalysis. **Cryogenic Equipment**—dewars, pumps, expansion engines, heat exchangers. **Cryogenic Properties**—mechanical, electrical, thermal, vacuum insulation, powder insulation. **Cryogenic Applications**—expansion engines and turbines, cryogenic fuels and oxidants, bubble chambers.

■ CLEVELAND, OHIO

September 7-13, 1957, Cleveland Auditorium. Annual Instrument Automation Conference & Exhibit of the Instrument Society of America. Conference theme will be "Instrumentation for Systems Control." About 500 individual exhibits will depict latest developments in the field. About 100 papers will be presented followed by informal discussions. Exhibit will be open Monday, Sept. 9, 2-10 P.M.; Tuesday, Sept. 11, 10 A.M.-6 P.M.; Wednesday, Sept. 11, 10 A.M.-6 P.M.; Thursday, Sept. 12, Noon-10 P.M.; Friday, Sept. 13, 10 A.M.-4 P.M.

Clinic sessions over weekend preceding exhibit. A.I.Ch.E. members are invited to register at same rate as ISA members.

■ ANNUAL—CHICAGO, ILL.

December 8-11, 1957. Conrad Hilton Hotel.

TECHNICAL PROGRAM CHAIRMAN: Henry F. Nolting, Standard Oil Co., 2400 New York Ave., Whiting, Ind.

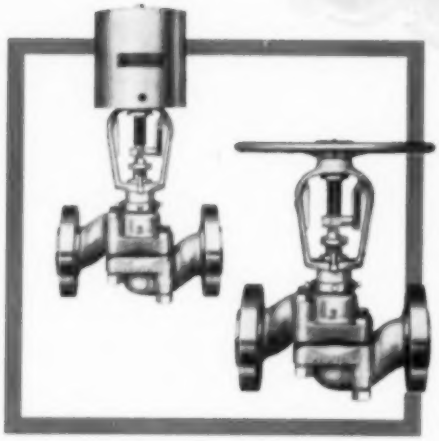
News of month-to-month developments in the Chicago Annual Meeting program is promised by **Henry Nolting**, technical program chairman. . . . **Fluidization** symposium, being organized by **Gilliland** of M.I.T., will concentrate on fundamental mechanisms . . . New co-chairman of **Nofsinger's Effective Cost Control** symposium is **Frank Fisher** (Sinclair Research) who explains that the phenomenon of narrowing profit margins in these times of unprecedented sales volumes is driving management to demand better and closer controls over unit product costs. . . . The step-by-step evaluation concept will be main theme of **Nofsinger's** session on **Project**

(*Continued on page 126*)

TOP HAND

...where Management
...Production and
Maintenance
are concerned!





ANNIN VALVES *meet every test of reliability, response and easy maintenance at low cost*

ANNIN VALVES are the only valves that meet the rigorous requirements of the missile program and the exacting demands of the modern process industries in a single standard construction at no premium.

- **MANAGEMENT** prefers Annin Valves because of low initial cost and low maintenance and spare parts inventory.
- **PRODUCTION** men prefer Annin Valves because of longer on-stream service and better product control.
- **MAINTENANCE** men prefer Annin Valves because of ease of maintenance and simplicity of modification for other services.

ANNIN *Control* **VALVES**

THE ANNIN COMPANY
DIVISION OF THE ANNIN CORPORATION
6570 Telegraph Road, Los Angeles 22, California

CUSTOM ENGINEERED RECTIFICATION

priced to compete with ordinary mass-produced equipment!



Sel-Rex
GERMANIUM • SELENIUM
RECTIFIERS

Sel-Rex Rectifier users include the country's foremost electrical and electronic concerns* — companies best qualified to evaluate rectifier equipment — who repeatedly specify and install Sel-Rex. Such recognition is not the result of "blue sky thinking" or "gimmick" models or lines...it is the result of delving into cold, hard engineering facts and coming up with the right answers for our customers. Let Sel-Rex custom-design rectification to suit you...it costs no more than ordinary, mass-produced equipment — in the long run, it will cost far less. *Names on request

Write Dept. CEP-7

Rectifier Division
SEL-REX CORPORATION
NUTLEY 10, NEW JERSEY
Offices: Detroit—Chicago—Los Angeles

REACH All Overhead Valves without DANGER!

REACH for Babbitt

Adjustable
SPROCKET RIM
with Chain Guide

- Eliminate dangerous catwalks, ladders, balconies, boxes, stools, etc.
- Prevent accidents, protect personnel
- Reach inaccessible areas easily
- Operate every valve from plant floor
- Easy to install and operate
- No maintenance, first cost, only cost
- Easy instructions with each unit
- Packed, completely assembled, one to a carton
- Fits any size valve wheel
- Your supplier carries complete stock
- Write for new descriptive Catalog sheet and prices:



Babbitt STEAM SPECIALTY CO.

6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.

FUTURE MEETINGS

■ ANNUAL—CHICAGO, ILL.

(Continued from page 124)

Evaluation. . . . Chemical Engineering Abroad, led by **Shelby Miller,** will be an insider's report by travelled members of A.I.Ch.E. on the who, what, and where of chemical engineering progress in Germany, France, Italy, Holland, Russia. . . . **G. Fred Ours,** who heads up the symposium on **Corrosion Resistant Materials of Construction,** promises "useful information on the general methods that can be used in solving corrosion difficulties" . . . **G. W. Blum's** symposium on **Laboratory and Pilot Plant Techniques** promises to cover all phases—planning, operation, size, kind of pilot plants. . . . Legal controversy over **Heavy Water Production** symposium expected to be cleared up soon, reports chairman **W. P. Bebbington.** . . . Behavior of materials and equipment will be focal point of **Joe Martin's** session on **Radiation Processing . . . Nuclear Process Heat,** organized by **B. W. Gamson** (Borg-Warner), to delve into chemical processing applications of heat from various reactor systems. . . .Also under **Gamson's** leadership, new and novel systems of **Extractive Metallurgy** will be explored. . . . Horizontal and vertical communications within a company are of equal importance in **Selling a Technical Program** to management—chairman, Dennis Murphy (Pan American Oil) . . . How are shock waves initiated and propagated? **Stuart Churchill's** symposium **Shock Waves in Process Equipment** should clear up many mysteries for chemical engineers. . . . "Not what may be done in the future but what is already being done now with computers in chemical engineering" to be highlighted in session on **Impact of Computers,** says chairman **Leon Cooper. . . . Separation of Materials in Biological Processes** to emphasize new developments in the pharmaceutical industry—chairman, **Elmer Gaden** of Columbia Univ. . . . **R. P. Whitney's** session **Chemicals Recovery in the Paper Industry** to attack a crucial chemical engineering problem: recovery of useful by-products from waste liquors.

Note: for those interested in submitting papers, names and addresses of the individual symposium chairmen are listed in **CEP,** June, 1957.

■ 1958 MEETINGS

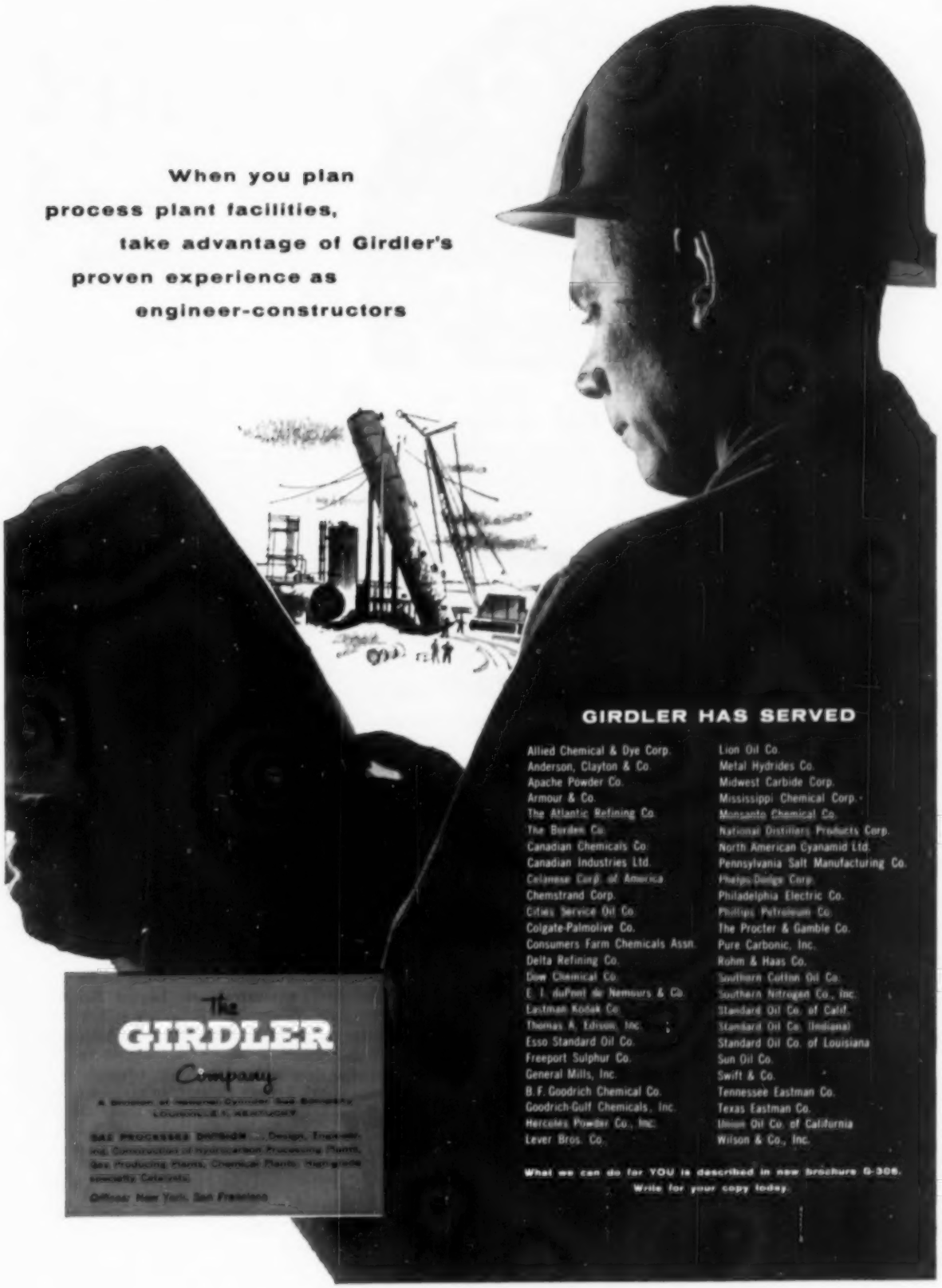
• Chicago, Ill., March 17-21, 1958. 1958 Nuclear Congress. Managed by A.I.Ch.E. Coordinated by E.J.C. Will include 4th Nuclear Engineering and Science Conference, 4th International Atomic Exposition, 6th Atomic Energy in Industry Conference, 6th Hot Laboratories and Equipment Conference, and the American Power Conference.

• Montreal, Canada, April 20-23, 1958. Sheraton-Royal Hotel. Joint A.I.Ch.E.-C.I.C. Conference. A.I.Ch.E. CHAIRMAN: Kenneth Beatty, North Carolina State College, Raleigh, N. C. CO-CHAIRMAN: W. H. Gauvin, McGill University, Montreal. **Chemical Engineering Aspects of Heavy Water Power Reactors**—CHAIRMAN: Donald Stuart, Evaluation Section, Civilian Power Reactors Branch, A.E.C., Washington 25, D. C.

• Philadelphia, Pa. June 22-27, 1958. Bellevue-Stratford Hotel. A.I.Ch.E. Fiftieth Anniversary Meeting. CHAIRMAN Roy Kinckiner, DuPont, Wilmington, Del. Theme for program is: **A Look to the Future.** All symposia and papers are being planned in accordance with this theme.

(Continued on page 128)

When you plan
process plant facilities,
take advantage of Girdler's
proven experience as
engineer-constructors



The
GIRDLER
Company

A division of National Cylinder Gas Company
LOUISVILLE 1, KENTUCKY

GAS PROCESSES DIVISION ... Design, Engineering, Construction of Hydrocarbon Processing Plants, Gas Producing Plants, Chemical Plants. Holds gasoline specialty Celanese.

Offices: New York, San Francisco

GIRDLER HAS SERVED

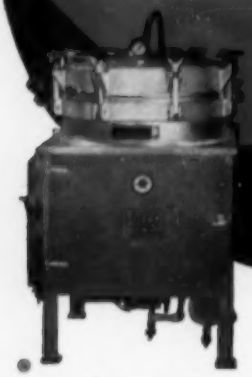
Allied Chemical & Dye Corp.
Anderson, Clayton & Co.
Apache Powder Co.
Armour & Co.
The Atlantic Refining Co.
The Borden Co.
Canadian Chemicals Co.
Canadian Industries Ltd.
Celanese Corp. of America
Chemstrand Corp.
Cities Service Oil Co.
Colgate-Palmolive Co.
Consumers Farm Chemicals Assn.
Delta Refining Co.
Dow Chemical Co.
E. I. duPont de Nemours & Co.
Eastman Kodak Co.
Thomas A. Edison, Inc.
Esso Standard Oil Co.
Freeport Sulphur Co.
General Mills, Inc.
B.F. Goodrich Chemical Co.
Goodrich-Gulf Chemicals, Inc.
Hercules Powder Co., Inc.
Lever Bros. Co.
Lion Oil Co.
Metal Hydrides Co.
Midwest Carbide Corp.
Mississippi Chemical Corp.
Monsanto Chemical Co.
National Distillers Products Corp.
North American Cyanamid Ltd.
Pennsylvania Salt Manufacturing Co.
Phelps Dodge Corp.
Philadelphia Electric Co.
Phillips Petroleum Co.
The Procter & Gamble Co.
Pure Carbonic, Inc.
Rohm & Haas Co.
Southern Cotton Oil Co.
Southern Nitrogen Co., Inc.
Standard Oil Co. of Calif.
Standard Oil Co. (Indiana)
Standard Oil Co. of Louisiana
Sun Oil Co.
Swift & Co.
Tennessee Eastman Co.
Texas Eastman Co.
Union Oil Co. of California
Wilson & Co., Inc.

What we can do for YOU is described in new brochure G-306.
Write for your copy today.

HILCO

provides *lower* vacuum pump maintenance costs . . .

increased vacuum-



OIL RECLAIMER

HILCO OIL RECLAIMER

purifies vacuum pump oil by continuous recirculation, either on a full-flow or by-pass basis, or intermittently on a batch basis, depending upon the requirements and physical layout of your plant.

HILCO OIL RECLAIMER SYSTEMS are the finest available for VACUUM PUMP users

A simple, economical and efficient method of restoring contaminated lubricating and sealing oil to the full value of new oil. HILCO Oil Reclaimers are used for the purification of vacuum pump oil in conjunction with the manufacture of transformers, condensers, capacitors, drugs, vitamin concentrates, radio tubes and light bulbs, essential oils, optical lenses, refrigeration compressors, titanium and many other products. A HILCO will produce and maintain oil free of all solids, sludge, acid, moisture, solvents, and dissolved gasses and restore viscosity, dielectric strength and other specifications to new oil value.

THERE IS A HILCO FOR EVERY OIL PURIFICATION JOB . . . AND EACH OFFERS YOU

These Features!

- Continuous, all electric, automatic operation.
- Low operating temperature.
- Vacuum processing.
- Infrequent operation—low operating costs.



WRITE TODAY! *For Complete Details Ask For Bulletin R-160*

THE HILLIARD *Corporation*

144 WEST FOURTH ST. ELMIRA, N. Y.

IN CANADA: Upton-Bradeen-James Ltd., 890 Yonge St., Toronto; 3464 Park Ave., Montreal

FUTURE MEETINGS

■ **1958 MEETINGS**

(Continued from page 126)

• August 18-21, 1958. A.I.Ch.E.-A.S.M.E. Heat Transfer Conference. CHAIRMAN: A. S. Foust, Dept. of Chem. Eng., Lehigh University, Bethlehem, Pa.

• Salt Lake City, Utah, September 21-24, 1958. CHAIRMAN: E. B. Christiansen, Dept. of Chem. Eng., Bldg. 437, Univ. of Utah, Salt Lake City. **Air Pollution**—CHAIRMAN: W. L. Faith, Air Pollution Foundation, 704 S. Spring St., Los Angeles 14, California. **What's New in Liquid Metals Technology**—CHAIRMAN: Marshall Sittig, American Lithium Institute, Inc., P. O. Box 549, Princeton, N. J.

• Cincinnati, Ohio, December 7-19, 1958. Netherland Plaza Hotel. A.I.Ch.E. Annual Meeting. TECHNICAL PROGRAM CHAIRMAN: A. C. Brown, Emery Industries, Inc., June & Long Streets, Ivorydale, Ohio. **Water Pollution**—chairman to be named. **Distillation**—CHAIRMAN: W. C. Schreiner, M. W. Kellogg Co., 711 Third Ave., New York 17, N. Y. **High-Speed and Time-Lapse Photography in Chemical Engineering**—CHAIRMAN: J. W. Westwater, William Albert Noyes Laboratory, Univ. of Illinois, Urbana, Ill. **Kinetics & Rate Processes**—CHAIRMAN: H. E. Hoelscher, Dept. of Chem. Eng., Johns Hopkins Univ., Baltimore 18, Md.

UNSCHEDULED SYMPOSIA

Proposed, but unscheduled, symposia of the Institute may be found listed in April CEP, page 114. Correspondence on proposed papers is invited by the program chairmen.

Papers are invited for the 3rd U. S. National Conference of Applied Mechanics to be held at Brown University, Providence, R. I., on June 11-14, 1958. Papers should be original experimental work, or theoretical contributions, in such areas as mechanics of rigid bodies and deformable solids, mechanics of fluids and gases, thermodynamics and heat transfer. Deadline for submission is January 1, 1958, but the committee urges sending manuscripts sooner to avoid last-minute overwork. □

The first Conference to be devoted exclusively to Liquid Scintillation Counting will be held at Northwestern Univ., Evanston, Ill., August 20-22. Most phases of the field and its applications will be covered, National Science Foundation has awarded $4,000 to the university to cover the cost of bringing five specialists to the conference from England, France, and Germany. □

The National Gas Chromatography Conference of the Instrument Society of America will be held August 28-30 at Michigan State University, East Lansing, Mich. □



EXON 470...specifically for protective coatings at lower costs

...typical of the Pin-Pointed Properties in Exon Vinyl resins

Manufacture of solution protective coatings takes a giant stride toward simpler processing and lower costs when you use Exon 470. You no longer need several resins to get the best properties of them all. One is enough . . . Exon 470.

With only one resin to work with, production control is simplified. Costs drop. At the same time you cut your inventory expenses. You produce a better product with outstanding solution characteristics.

Here are just a few of the important properties combined in Exon 470: Adhesion to metal, alkyd and vinyl surfaces. High solubility in aromatic hydrocarbons. Alkyd compatibility. Excellent pigment dispersion properties. Abrasion, acid and alkali resistance. Fast baking . . . medium fast drying. Oil, grease and salt-spray resistance. Low moisture vapor permeability. Outdoor durability. Now you need only one resin . . . Exon 470 . . . to make better solution coatings at lower costs.

Exon 470 is just one of the many resins in industry's most complete line of versatile vinyls. It is another reason why industry looks to Firestone for engineering answers to its needs.

Consider your own production problem. Then, for resin properties pin-pointed to the best answer for you, check with Firestone.

Firestone
EXON
RESINS

For complete information and technical service, call or write:

CHEMICAL SALES DIVISION: FIRESTONE PLASTICS COMPANY

DEPT. 746 J, POTTSTOWN, PA. • A DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

IN CANADA, CONTACT CHEMICAL SALES DIVISION, FIRESTONE TIRE AND RUBBER COMPANY OF CANADA LTD., HAMILTON, ONT.

INDUSTRY'S MOST COMPLETE LINE OF VINYLS ENGINEERED TO YOUR SPECIFIC NEEDS

Now available to designers, manufacturers, and users of shell and tube heat exchangers is a simple, practical

Guide To Heat Exchanger Testing



While the A.I.Ch.E. Standard Testing Procedure for Heat Exchangers * is intended to serve as a guide to the whole chemical processing industry, it is particularly designed to aid smaller companies which are not sufficiently staffed and equipped to have evolved highly-developed testing procedures of their own and which, as a consequence, have been forced to rely on their confidence in the firm supplying the equipment. On the other hand, designers and manufacturers of processing equipment do not always have on hand facilities for testing of their equipment under the full-scale service conditions which it is designed to meet.

* A.I.Ch.E. Standard Testing Procedure, Heat Exchangers, Section 2, Condensers (1956) is the work of an A.I.Ch.E. committee headed by C. H. Gilmour of Union Carbide Chemicals Co. A.I.Ch.E. Sub-committee on Heat Exchangers: C. H. Gilmour (chairman), W. C. Beckley, C. F. Bonilla, W. M. Cooper, S. A. Guerrieri, R. M. Hubbard, M. W. Martin, P. S. Otten.

Special Types of Equipment

Scope of the Procedure is limited to heat transfer in shell and tube condensers, which by definition are exchangers in which condensation occurs on one side without change of phase of the cooling medium on the other. It is intended to include condensers in which the condensate is sub-cooled. It is not intended to cover power plant type surface condensers, as these are adequately covered by the A.S.M.E. Code "Steam Condensing Apparatus," published in 1938.

Agreeing on Acceptance Tests

Key section of the Procedure is, of course, the one which deals with factors which should be agreed upon between vendor and user when tests are run for acceptance under a purchase contract. It is highly desirable, for instance, that prior agreement be reached between purchaser and manufacturer concerning the methods of calculation and the actual heat transfer equations used by the manufacturer in sizing the equipment covered by the contract.

The performance test should be run under design conditions, if possible. However, since it is seldom possible to test a condenser under exact design conditions, the test results must be analyzed and interpreted to determine whether the condenser would operate satisfactorily under the designed conditions.

Areas of uncertainty will always remain, even assuming that all temperature, flow, and pressure measurements have been made properly. Analysis of the data requires knowledge of the active condensing area, the effect of vapor velocity, mass diffusion, tube orientation and layout, and the temperature gradient. In addition, purchaser and vendor should agree concerning the methods which will be used to vent the unit during the test.

Fouling Resistance Factor

It must always be borne in mind that heat must flow through the fouling resistances on both sides of a tube, as well as through the tube wall itself. In the design of all heat transfer equipment, therefore, a "fouling factor" is employed which is intended to provide sufficient overcapacity to guarantee design performance when the equipment is in a partially fouled condition. An important secondary purpose of the present Procedure is to accumulate data on fouling resistances in this type of equipment. At present, little reliable data exists in this area, and this fact is a frequent source of differing interpretations by vendors and purchasers of heat transfer equipment. It is recommended by the Procedure that a definite fouling factor be specified by the user before competitive bidding starts, and that all designers and fabricators bidding on a piece of equipment use this same factor so that the equipment can be compared on an equitable basis.

Setting Up the Test Conditions

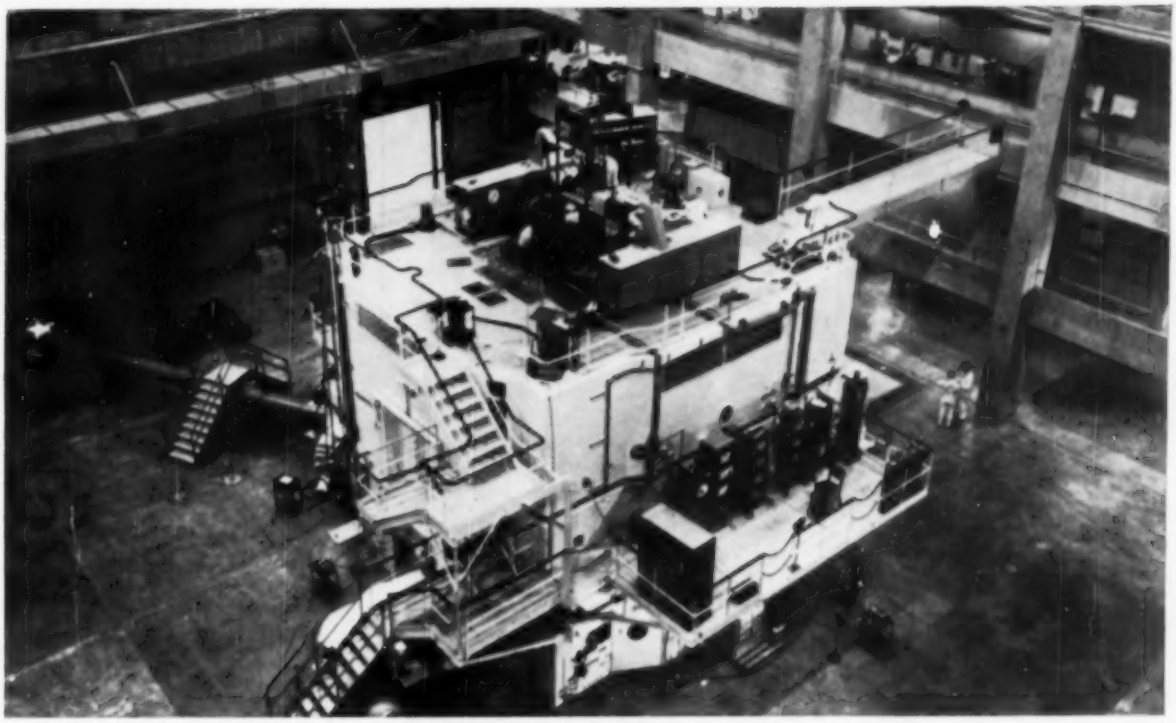
This section of the Procedure can be considered as a sort of "check list"

(*Continued on page* 132)

"KERODEX" protected hands wash clean without scrubbing.



"KERODEX" spreads on like a cream but acts like an invisible glove to shield the skin from the vast majority of industrial irritants such as acids, alkalis, solvents, paints, cutting oils, and resins. "KERODEX" does not smear. It does not affect materials handled, nor is it affected by them. Two types of "KERODEX" are available for "wet" and "dry" work. Write for full information on "KERODEX"® barrier creams to Ayerst Laboratories, 22 East 40th Street, New York 16, N. Y. 5759



World's FIRST testing reactor—the Atomic Energy Commission's materials testing reactor at Idaho Falls, Idaho. Blaw-Knox served as architect-engineer. Neutron "chopper" tube is on main floor, left; control room is at end of bridge, upper right.

Blaw-Knox engineers two firsts in Atomic Testing Reactors

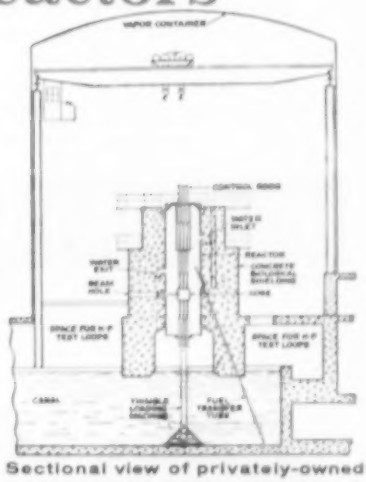
The need for testing reactors is so great that the Atomic Energy Commission has announced a new testing reactor policy, which encourages the building of testing reactors by private industry. As AEC states: ". . . a large part of its (the Commission's) requirements for test reactor facilities can be met with privately-owned reactors based on proved designs and technology."

Blaw-Knox has played a prominent role in developing this technology. Our experience includes serving as architect and engineers on:
. . . the world's *first* materials testing reactor for the AEC
. . . the world's *first* testing reactor for commercial use

With this background we are well prepared to serve you in—

- scoping the project
- preparing feasibility reports
- summarizing hazards reports
- detailing engineering
- procurement and fabrication of parts
- construction of the facility
- initial operation
- training of operators

We welcome the opportunity to work with you on any proposed project in this active field of nucleonics.



Sectional view of privately-owned testing reactor, engineered by Blaw-Knox, shows general assembly, control rods and pressure vessel.

BLAW-KNOX

BLAW-KNOX COMPANY

Chemical Plants Division • Pittsburgh 22, Pa. • Chicago 1, Ill.

Birmingham • New York • Philadelphia • San Francisco • Washington, D.C.

Designers, engineers and builders of plants for the process industries: chemicals • petroleum • petrochemicals • resins and plastics • nuclear energy • fats and oils • fertilizers • synthetic fuels



and here's why: It absorbs water instantly from gases and liquids in either a static or flowing system, is insoluble and will not swell or disintegrate in water. FLORITE gives a low dew point depression, and agressively resists "poisoning effects" which permanently destroy adsorption qualities.

Let us prove that Florite is the most economical of the granular agents and best suited to your desiccant requirements, too. Inquiries receive prompt attention.

FLORIDIN COMPANY Adsorbents Desiccants Diluents

DEPT. Z P.O. BOX 989 TALLAHASSEE, FLORIDA

TRY "TP" (Thermal Precipitation) for precise dust determinations



5 DIFFERENT MODELS employing Continuous Oscillating or Gravimetric Methods. For obtaining ACCURATE samples, use The FICKLEN Method. Tell us your dust problems.

Joseph B. Ficklen, III, 1848 East Mountain Street, Pasadena 7, California
"T P" Engineers for 20 years.

HEAT EXCHANGERS

(*Continued from page* 130)

such as is used by airplane crews before each takeoff, to be absolutely sure that no essential factor has been overlooked. The list of test factors given here has been built up on the basis of commercial testing experience; these are things which have actually happened during full-scale tests. It is pointed out, for example, that one should make sure that the system is completely tight before the testing cycle is started. Such a statement seems almost too obvious; however, many tests have been invalidated simply because someone forgot to close a by-pass connection.

Methods of Measurement

Sampling connections should always be provided for in the design stage. The Procedure goes into considerable detail as to where to locate them. For example, in multipass exchangers, connections should always be installed between passes as well as at the inlet and outlet points; this is essential for trouble-shooting purposes. Often a simple pressure-drop test can determine the location of a stoppage without it being necessary to dismantle the whole piece of equipment.

Possibilities of error in measurement are treated in detail. Overall heat and material balances should be within ten per cent. Otherwise, "you are just not in business," according to Gilmour.

Careful consideration is given to measurement of flow rate in those cases where conventional means such as orifice meters, rotameters, or displacement meters cannot be used. In such cases, a suitable component may sometimes be added to either the vapor or liquid stream at a measured rate. Analysis after complete mixing has taken place will then permit accurate estimation of the flow rate of the stream to be measured.

Difficulty in taking representative vapor samples, particularly if entrainment is present, is one of the chief obstacles to the obtaining of accurate test data. In taking vapor samples, the sample connection should extend into the center of the pipe, preferably from the top, and have its opening headed downstream.

Running the Test

Practical test procedure is spelled out step-by-step. An extremely detailed treatment is devoted to means for cleaning the equipment prior to

testing. In using the Procedure, it will be noted that pressure drop measurements are based throughout on operation with clean tubes. The reason for this arbitrary working assumption is that, in the great majority of cases, there exists no practical way of measuring or estimating the thermal conductivity of a fouling layer.

Inlet and outlet nozzles should be included in pressure drop calculations both for design purposes and for testing. This point also is of importance because, in the past, varying practice in this respect has often led to misunderstandings between vendor and purchaser.

Computation of Results

All data taken should be averaged and the average values used for all computations. If the test data permit, heat transferred should be calculated both for the cooling medium and for the stream which is condensed. If the test is to be considered reliable, the two heat quantities should check within ten per cent of the smaller value.

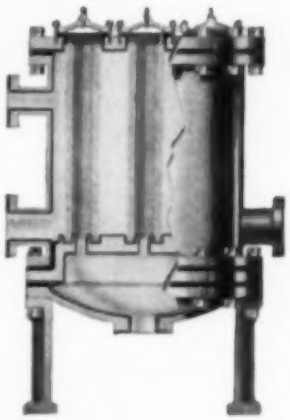
It is hoped by the many who have helped to create this Procedure that its wide dissemination will bring about industry-wide agreement on many points which have been difficult for manufacturers and users to resolve satisfactorily. As a sort of bonus, more widespread testing will mean more data available to designers of heat transfer equipment and, in the long run, more efficient equipment for everybody.

Copies are available from the Secretary's Office, A.I.Ch.E., at $1.00 a copy.

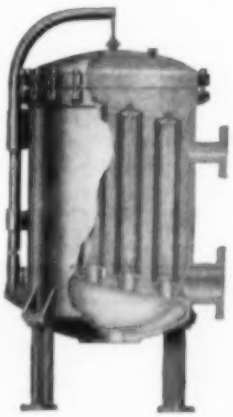
The Eighth National Conference on Standards will be held in San Francisco, St. Francis Hotel, November 13, 14, and 15, 1957. Conference will meet in conjunction with the thirty-ninth annual meeting of the American Standards Association, sponsor of the conference. Sessions will cover radiation exposure, electronics, industrial preparedness, motion pictures and television, purchasing, company standards, and technical communications. □

Mellon Institute has announced their decision to build a special building at their Bushy Run Laboratories near Pittsburgh to house the Chemical Hygiene Fellowship research group. The research group is sponsored by the Union Carbide Chemicals Co. and their activities are aimed chiefly at obtaining information leading to the safe use of the processes or products of the various divisions of Union Carbide. □

NEED A FILTER?
FOR CORROSIVE LIQUIDS



Adams CFR are rubber lined filters which meet corrosion problems that require this type construction. Where lead lining is a must, the Adams CFL filter will meet your needs. Each tubular element of either filter may be removed individually for inspection, or replacement.



Adams CVF Filters are available in Carbon Steel, Stainless Steel, Monel and Nickel construction. Also constructed with submerged head for personnel safety and with outer jacket for use with steam or refrigerated coolant to maintain desired temperature.

All Adams Filters provide safe cleaning without disassembly by a sudden, high velocity reverse flow of backwash liquid.

Do you have a filtration problem where corrosive liquids must be given a high polish? Where there is danger to personnel? Where there is a problem of temperature control?

The R. P. Adams Company has a line of filters which will solve any one of these problems . . . or a combination of all.

We may not have the answer to *your specific* problem, but the chances are we do. For the fastest action, we suggest you use the coupon below, or write for Bulletin 431 on your company letterhead.

R. P. ADAMS COMPANY, INC.

240 E. PARK DRIVE
BUFFALO 17, NEW YORK

R. P. ADAMS COMPANY, INC. JY-67
240 E. PARK DRIVE — BUFFALO 17, NEW YORK

We have a problem involving the filtration of corrosive liquids.
☐ Please send us your Bulletin 431.
☐ Ask your local representative to call on us.

Name _____ Title _____
Company _____
Street _____
City _____ State _____

WILL COMPUTERS REPLACE CHEMICAL ENGINEERS?

No! says panel meeting of Southern California Section. In fact, computer applications are going to require even more engineers than ever before.

According to a panel of four experts* at the April meeting of the **Southern California Section**, in the past three years the application of the high-speed electronic computer to chemical engineering problems has been firmly established as a paying proposition, and computers are now available to any company regardless of size.

Labeling the rise of computers as a second industrial revolution that will free men's minds from routine calculations, Blohm pointed out that the computer is capable of performing many manipulations which would be all but impossible any other way, and thus the chemical engineer is free to spend his time on more important matters. Computers are a great aid, not a replacement, for the chemical engineer. The giant machines can do wonders but not miracles. They cannot think—the final decision is still in the mind, training, and capabilities of the engineer.

Roberts emphasized that much of the difficulty in applying computers to the chemical engineering field has little to do with the computers but rather with the troubles of programming the chemical problem in terms of mathematics—and this is the chemical engineer's job. Many of the problems associated with proper construction of chemical engineering equipment, according to Ebersole, are time-consuming and tedious. Operations such as the rigorous design of distillation columns with tray to tray enthalpy balances would take a man-month of the engineer's time, in practice usually takes a week and gives a semirigorous solution, can be done by the computer in about one hour—after programming!

Far from replacing chemical engineers, Cheney said, the use of computers will absorb the talents of many additional engineers. In actuality, computer techniques offer many opportunities for engineers to enter more directly into the business aspects of plant operations.

The computer may relieve engineers of enough routine to help overcome the present short supply, but it will no more replace them than the slide rule did, Ebersole said. In fact, computers will only make the chemical engineer more productive.

Roberts, in summing up, said that the chemical engineer of the future will be adept at relating theory to practice, will have advanced training in statistics and higher mathematics, and due to the influence of computers, chemical engineering will be changed from its present state of a semi-art into a pure science.

All the panelists agreed that computer applications "will sop up chemical engineers as a sponge sops up water," will greatly affect chemical engineering as a profession, will open interesting and rewarding new fields.

—L. N. Miller

* C. L. Blohm, Fluor Corp.; S. M. Roberts, Union Oil Co. of Cal.; A. J. Ebersole, Fluor Corp.; L. K. Cheney, Richfield Oil Corp.



The Tidewater Virginia Section's (P. E. Stone) annual award to an outstanding student chemical engineer went this year to R. M. Hugh, a senior at VPI. Here section chairman B. L. Hinkle (left) presents the certificate of award to Hugh. Based primarily on scholarship, the award consists of one year's dues to A.I.Ch.E. as well as the certificate.

It's ACE for POLYETHYLENE WARE

1204-3 BOTTLE with Finger Ring





Light - Sturdy
Unbreakable
Chemically
Resistant
Buttressed with
Screw Caps

1204-1 BOTTLES and CARBOYS

Cap. gallon	1/2	1	2	5	6½	13
Price each	2.75	3.85	7.45	12.75	15.00	23.50

1 gal. cap. only $4.45 each, less 10% in case lots of 6.

They may be used for shipping and storage of corrosive chemicals and standards. Also useful for distilled water storage since they will not change the pH of the water, and are easily and safely transported to point of use.

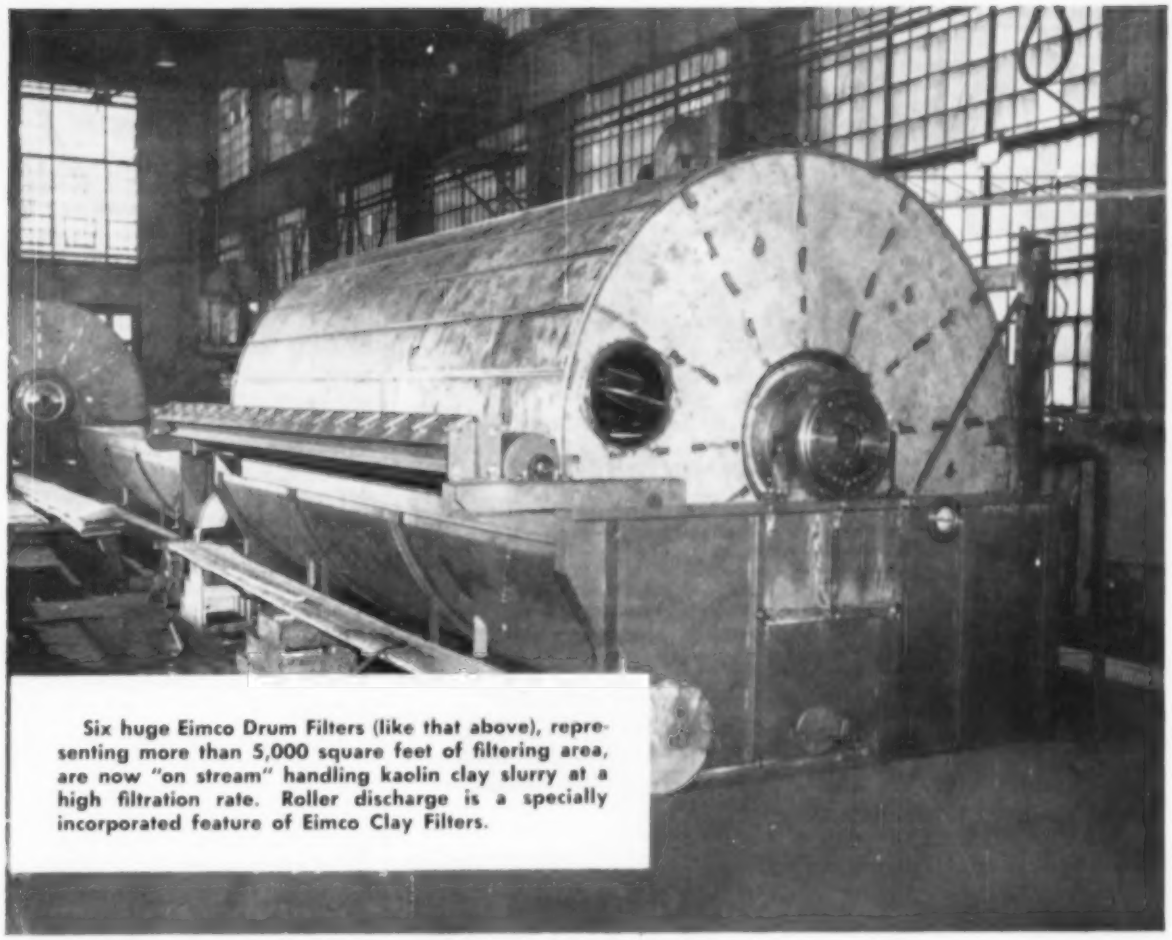
For Polyethylene Folders Write Dep't PW- G

ACE GLASS INCORPORATED
VINELAND ♠ NEW JERSEY
LOUISVILLE, KY., 639-41 SOUTH HANCOCK ST.
Glassware Specialists to Industry and Research

PNEUMATIC CONVEYING, EDUCATION OF ENGINEERS, SOLAR ENERGY, ARE MAJOR SUBJECTS AT LOCAL SECTION MEETINGS

There is no distinct line separating high pressure and low pressure conveying, according to T. V. Reinauer of Pulverizing Machinery Division, Metals Disintegrating Co., who spoke to the May meeting of the **East Tennessee Section** (*A. J. Peacock, Jr.*). But Reinauer then defined a low pressure system as that point in the design where the flow can be treated as being

(*Continued on page* 136)



Six huge Eimco Drum Filters (like that above), representing more than 5,000 square feet of filtering area, are now "on stream" handling kaolin clay slurry at a high filtration rate. Roller discharge is a specially incorporated feature of Eimco Clay Filters.

FOR A KAOLIN CONCENTRATOR

24 Foot Eimco Drum Filters Cut Costs In Half

THE INSTALLATION: Six Eimco 24' x 11' 6" Stainless Clad Vacuum Drum Filters, largest metal deck drum filters ever shipped assembled. (Over-all dimension 14' wide x 31' long.)

THEIR JOB: To materially reduce the costly operation of a plate and frame press station filtering two grades of kaolin coating clay slips.

RESULT: 50% reduction in costs. Based on capital outlay and labor, operating and maintenance expenses . . . this firm is producing a ton of dry clay for half the cost using Eimco Clay Filters.

CUSTOM DESIGN PAYS OFF AGAIN! Like all Eimco Filters, these huge drums were especially designed to process the slurry of a particular industry . . . based on extensive testing and research. Then—thru accurate conclusions provided by pilot plant tests—the filters were "detail engineered" to fit the specific needs of this client, and **sized** to get the most production per manhour of attention.

You, too, can profit from Eimco experience and precision construction. Write for details or talk with an Eimco Sales Engineer!

THE EIMCO CORPORATION

SALT LAKE CITY, UTAH

Research and Development Division, Palatine, Illinois • Process Engineers Inc. Division, San Mateo, California
Export Offices: Eimco Building, 51-52 South Street, New York 5, N. Y.
BRANCHES AND DEALERS IN PRINCIPAL CITIES THROUGHOUT THE WORLD

B-978



SEND FOR FUSED QUARTZ—FUSED SILICA DATA FILE



CENTER FOR HIGH-PURITY FUSED QUARTZ

The Amersil processes for producing and fabricating fused quartz and silicaware of critical purity, simplify your problems in securing the precise laboratory or industrial equipment required for your production.

Standard apparatus, crucibles, trays, cylindrical containers in a complete range of sizes and tubing (up to 25" diam.) are available for early delivery. Amersil engineers are available to assist in developing special equipment to individual requirements. Your inquiry is invited. ★ ★

- ROTOSIL
- OPTOSIL
- HOMOSIL
- ULTRASIL

AMERSIL COMPANY, INC. FUSED SILICA AND QUARTZ

685 RAMSEY AVE., HILLSIDE 5, NEW JERSEY

ENGELHARD INDUSTRIES

MANNING & LEWIS ENGINEERING CO.
28-42 OGDEN ST. NEWARK 4, N.J.
WORKING PRESS:- SHELL TUBES
UNIT NO. JOB NO.

HEAT EXCHANGE and PROCESS EQUIPMENT

M & L STILL REBOILER



Code Construction: A.S.M.E. Code Stamped and to T.E.M.A. Specifications

Materials: All Carbon Steel

Physical Dimensions: Shell—44" Dia., 8'9" Length 1 1/16" thick; 1500 Steel Tubes (¾" O.D. x 14 B.W.G.)

Test Pressure: 415 lbs.

Design Temperature: 450° F. **Weight:** 9500 lbs.

As a result of our many years of experience we at M&L have an unusually thorough knowledge of the appropriateness, adaptability and qualities of fabrication of a wide variety of metals. This accumulated knowledge, coupled with our engineering experience and the important "extras" in fabrication is your assurance of practical trouble-free equipment . . . at the lowest possible cost.

An excellent case in point, is the Still Reboiler illustrated above. In the fabrication of the Reboiler, every seam was x-rayed to make absolutely certain the welding job was perfect. This is typical of the "extra" care you can expect and get from M&L.

Why not call on us the next time you need equipment. We design and construct to A.S.M.E. and A.P.I. code or can build to non-code standards. Please state *all* conditions of service.

THIS NAMEPLATE IS YOUR GUARANTEE OF QUALITY

- Condensers
- Evaporators
- Jacketed Kettles
- Ribbon Mixers
- Agitators
- Reactors
- Pressure Vessels
- Heat Exchangers
- Reboilers

Manning & Lewis Engineering Company

DESIGNERS & MANUFACTURERS OF QUALITY HEAT EXCHANGE EQUIPMENT

28-42 OGDEN STREET NEWARK 4, NEW JERSEY

News of the Field

FROM LOCAL SECTIONS

(*Continued from page* 134)

based on an incompressible fluid and in which the line losses do not exceed forty inches of water. Air loading, or quantity of air used per pound of material, is another factor used in defining a low pressure system. This factor should be between 12 and 60 cubic feet of air per pound of material. A simple low pressure conveying system, Reinauer explained, consists of a pick-up, or feeder, station; duct work; a receiver-separator; and an exhauster. The feeder station must be designed so as not to overload the system. The duct work should be fabricated from 16 or 18 gauge sheet metal. The receiver-separator collects all the material conveyed and can be either a mechanical or filtration type separator. In a low pressure system the receiver can be housed in a non-reinforced shell and the excess air can be used for other purposes, such as cooling the conveyed solids. Inert gas can also be used for the fluid in a low pressure system and, because of the low velocities, traps can be inserted in the duct work and will work effectively.

May meeting of the **El Dorado Section** (*G. D. Rucker*) heard Fluidized Solids defined as "granular solids suspended on a stream of rising fluid, either gas or liquid." Speaker was J. W. Carr, Jr., Esso Research, Baton Rouge, La. This type of stream, Carr pointed out, has almost all the characteristics of a true fluid. There are four stages of solids and fluid mixtures: a non-fluid stage in which the solids lie against each other and do not move; a quiescent stage in which the solids begin to be disturbed; a turbulent fluid stage in which the solids are fluidized; and a dispersed suspension stage in which the solids are carried along with the fluid. The best particle size for a fluid bed is 20 to 80 microns with the average size being 40-70 microns. Larger particles cause slugging and smaller particles will pack. Some advantages of a fluid system are high heat transfer, isothermal conditions, excellent contacting and mixing, and ease of handling. Possible disadvantages are catalyst losses and erosion. Some uses for fluidized solids systems are fluid hydroformer, catalytic cracking, oil shale retorting, fluid coking, and absorbent systems. Absorbing systems using towers very similar to bubble tray towers have been used, according to Carr, to separate ethylene from propylene.

(*Continued on next page*)

Complete Corrosion Proof Plastic Ventilating And Exhaust Systems



. . . engineered and built to specifications, save maintenance dollars . . . cut downtime

■ Wherever corrosive fumes must be handled, Agilide (PVC) or Agilene (polyethylene) exhaust and ventilating systems will do the job at far less cost. Made entirely of rigid and durable plastic, they afford *complete* protection from corrosion. There are no coatings to chip or peel — no weak spots and no metal parts to corrode.

Agilene (polyethylene) and Agilide (PVC) installations are widely used in the chemical and allied industries, as well as for pickling, plating and reactor exhausting, dust removal, etc. They quickly pay for themselves by outlasting previously used materials.

Write for full details on Agilene and Agilide corrosive resistant exhaust systems . . . there are components to cover all phases of fume ventilation from the exhaust hood — to fan — to the weather cap above the roof.



Agilene (polyethylene) exhaust hoods can be built to your specifications.



Agilene (polyethylene) seamless ducting and duct fittings are available from stock in a variety of sizes.



Agilene (polyethylene) centrifugal fans are fabricated completely of plastic in capacities from 185 to 2350 CFM.

AMERICAN AGILE Corp.

5461 DUNHAM RD. • MAPLE HEIGHTS, O.

AGILENE AGILIDE

Acknowledged pioneers in the welding and engineering of structural plastics.

Solar Energy and India

Homeowners can go into the utilities business when energy from the sun is delivered to the ultimate consumers. All that is needed is a small unit in the backyard consisting of: a parabolic mirror assembly of about 20 square feet; photoelectric junctions at focal points of mirrors; and lead storage batteries for no-sun days. Ultimately this unit should cost about $700, according to J. F. Flagg of General Electric, who explored the future of solar energy for the **Western Massachusetts Section** (*R. T. Bogan*) at its annual Pittsfield, Mass., meeting in May.

Solar energy can be used for heat, photosynthesis, and photoelectronics, and if only one per cent of the total solar energy that hits the earth annually could be collected, the earth's entire energy needs for the year 2000 could be collected in three days. The present costs for home sun energy converters are $800-900 per unit area. Flagg believes these costs can be drastically reduced. The commercial use of solar energy is within reach of possibility when there is economic justification. This condition does not exist today with the break-even point for central utilities at 4¢ a kw-hr.

The process industries are taking a prominent part in the modernization and industrialization of ancient India. Speaking to the February meeting of the **Oklahoma Section** (*E. R. Beck*), H. B. Irvin, who recently spent three weeks touring northern India on a technical survey made by a team of Americans and Indians, showed that the Indian Government has estimated that the equivalent of about $2.9 billion will be spent for industrial expansion in the second five-year plan (1956-1961). About a third of this is planned for the chemical industries, with plants to manufacture fertilizers, petroleum products, sugar, alcohol, pharmaceuticals and drugs, heavy chemicals, synthetic rubber, and vegetable oils. Some of these plants are being financed and built by the Indian Government, others are being handled in the private sector or by private enterprise. In many cases, technical know-how and complicated equipment are being supplied by foreign companies or foreign governments. Most of the large plants recently completed or under construction are of modern design and well instrumented. (Examples are the refineries of Stan-Vac and Shell at Trombay, and the government's Sindri fertilizer plant.) But the great obstacles to the development of chemical industry in India are the scarcity of technical personnel and the lack of

(*Continued on page* 138)

Got a Production Bottleneck?



FOR PRODUCT ANALYSIS and COST ESTIMATES on NEW FILTRATION EQUIPMENT SEE...

SPERRY

Your Headquarters For

FILTER PRESSES

— all sizes, all types for all requirements. Available with center, side or corner feed; open or closed delivery; simple or thorough washing; jacketed plates for filtering at high or low controlled temperatures.

LABOR SAVING DEVICES

including Plate Shifters for easier, safer handling of plates and frames . . . and Closing Devices in a full range of models to facilitate openings and closings of new Sperry Filter Presses or existing presses in the field.

FILTER BASES—cotton, paper, synthetics and woven metals — plus special cloths for special requirements. Plain or punched.

Mail coupon for your copy of the **SPERRY FILTRATION CATALOG,** complete with illustrations and specifications to help you plan new filtration facilities.



D. R. SPERRY & CO.

BATAVIA, ILL.

Sales Representatives

George S. Tarbox — 808 Napperhan Ave., Yonkers, New York

Alldredge & McCabe — 847 E. 17th Ave., Denver 18, Colo.

B. M. Pilhashy — 833 Merchants Exchange Bldg., San Francisco, Calif.

Texas Chemical Eng. Co. — 4101 San Jacinto, Houston, Texas

D. R. Sperry & Co. CEP-7
Batavia, Ill.
Please send me a free copy of the Sperry Filtration Catalog.

Name_____

Company_____

Address_____

City_____ State_____

News of the Field
FROM LOCAL SECTIONS

(*Continued from page* 137)

technical know-how. The process industries must still rely primarily on a limited number of engineers and chemists trained in North America and Europe; attempts to introduce technical education in culture-minded India have not been too successful as yet.

Education of Chemical Engineers

Student scholarships, awards, and guidance were high on the agenda of the local sections in recent months. Annual scholarships in the amount of $250 each have been established by the **South Texas Section** (*E. W. Bowerman*) at Rice Institute, Texas A&M College, University of Houston, and University of Texas. The scholarships will go to students already majoring in chemical engineering, or to high school seniors who have expressed an intent to study chemical engineering and who reside within the boundaries of the section and show a need for financial assistance. The section gives the college or university full responsibility and latitude for awarding and administering the A.I.Ch.E. scholarships.

Gary J. Watts, senior chemical engineering student at Lamar State College of Technology, Beaumont, Tex., is the first place winner in technical paper competition among **Southwest Regional Student Chapters** of A.I.Ch.E. The paper that won Watts $50 and a certificate was "Graphic Determination of Isothermal Vapor Pressure Equilibrium."

The **Syracuse Section** (*I. W. Wolf*) reports that its activities in aiding educational programs have been wide. The high school subcommittee of the section was instrumental in organizing a county-wide "Technical Council on Education" which is made up of a representative from each technical society, science teachers, math teachers, and career guidance counsellors. The Council's activities have been in the area of coordinating needs and aids in science and math teaching, and organizing interest stimulants in schools where they are needed. The University-Industry Subcommittee organized a series of seminars in which local men from industry and Syracuse Univ. talked on technical matters.

The **Dallas Section** participated in a big get-together of the Engineers Club of Dallas in which they had their annual dinner for future engineers. Attending were 300 high school seniors, and each boy sat with a sponsor from his future field.

A particularly interesting plant trip to U. S. Naval Powder Factory, Indian Head, Md., was the May meeting of the **National Capital Section** (*J. L. Gillman, Jr.*). The tour was classified "confidential" and covered mainly the facilities for producing modern propellants. These included the powder grain pilot plant and the new continuous Biatti process nitroglycerine pilot plant. S. Skolnik, director of research at the factory, gave a talk explaining in general the processes employed at the factory.

Also Meeting . . .

Knoxville-Oak Ridge Section (*R. W. Horton*) toured the Bowater Southern paper plant at Calhoun, Tenn., at its May meeting. A new, modern mill, the Bowater plant turns out 300,000 tons of newsprint a year, ⅓ of that used in the South. . . . **Rochester Section** (*F. L. Wells*) heard H. T. Maijgren, asst. to the president of Franklin Cole and Co., discuss the investment field from the standpoint of the individual investor.

(*Continued on page* 143)



SAVE THOSE BACK ISSUES

Every so often an unprecedented demand for a particular issue, or an unexpected influx of new subscribers and members puts the editor in the embarrassing position of running out of copies of Chemical Engineering Progress. This has happened several times in our short history and if members have copies of any of the following issues, we would be glad to purchase them. The issues which we need and for which we will pay 75 cents each are: Jan., Feb., 1948; Jan., 1949; Feb., 1951; Nov., 1955; Jan., March, 1956; Jan., April, 1957.

All these issues were over-printed to the usual extent, but because popular features spurred single copy sales, our reserves are exhausted.

Send your back numbers of issues specified above to Editor, Chemical Engineering Progress, 25 W. 45 St., New York 36, N. Y., and help fellow members.



How Allis-Chalmers Can Help You

Cut Heat Transfer Costs

Obtaining increased production, lower processing costs and improved product quality is more than a matter of installing the best heat transfer equipment. Maximum utilization of that equipment also calls for an *efficient flow design*. You get *both* from Allis-Chalmers.

A-C Engineers Work With Your Staff or Consulting Engineers

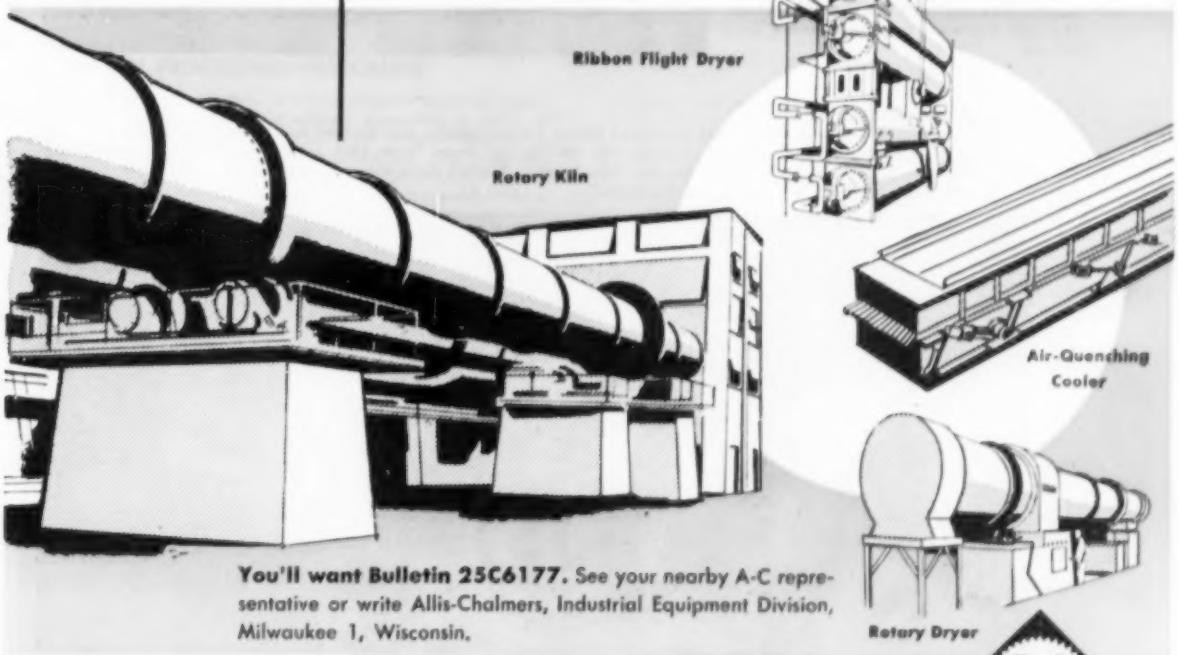
Allis-Chalmers engineers concern themselves with overall operation . . . the evaluation of variables . . . plant design . . . the integration of interdependent equipment into a complete process.

Pre-recommendation research, testing and, of course, expert installation and localized field service are also available from Allis-Chalmers — the world's leading manufacturer of rotary kilns, coolers and associated equipment.

Equally important is the fact that Allis-Chalmers interest in your problems is continuous. Laboratory services, periodic equipment check-up and parts service are yours for the life of the equipment — and a long life it is, too.

Partial List of Material Processed with Allis-Chalmers Heat Transfer Equipment

- Limestone
- Lime
- Dolomite
- Magnesia
- Alumina
- Bauxite
- Manganese Oxide
- Iron Ore
- Phosphates
- Refractories
- Foundry Sand
- Petroleum Sand
- Petroleum Coke
- Fuller's Earth
- Nickel Ores
- Copper

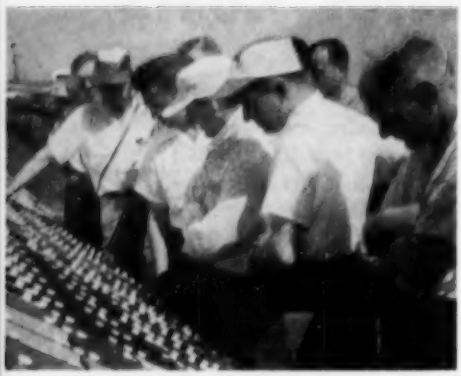


You'll want Bulletin 25C6177. See your nearby A-C representative or write Allis-Chalmers, Industrial Equipment Division, Milwaukee 1, Wisconsin.

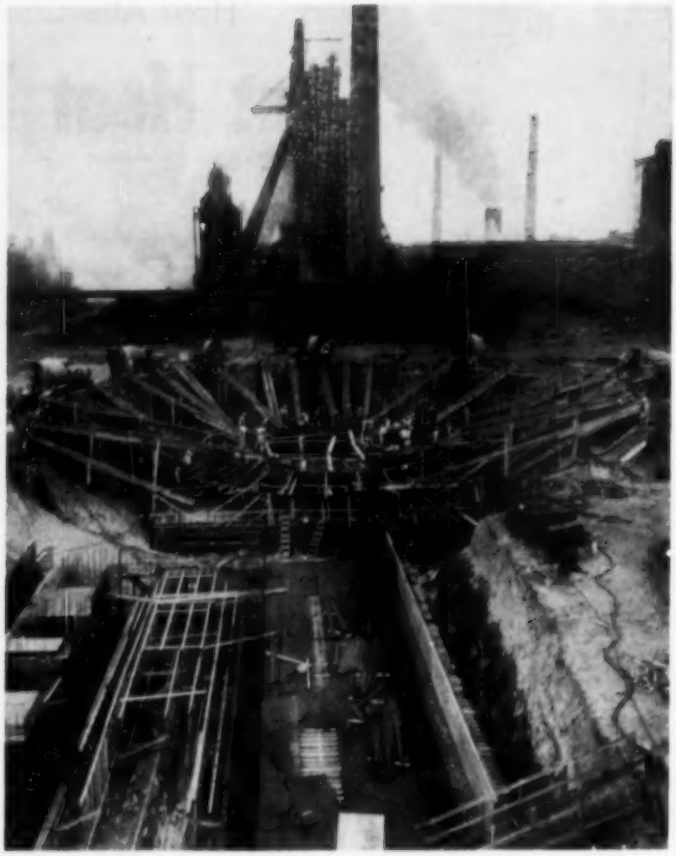
ALLIS-CHALMERS

A-5325

CEP CAMERA



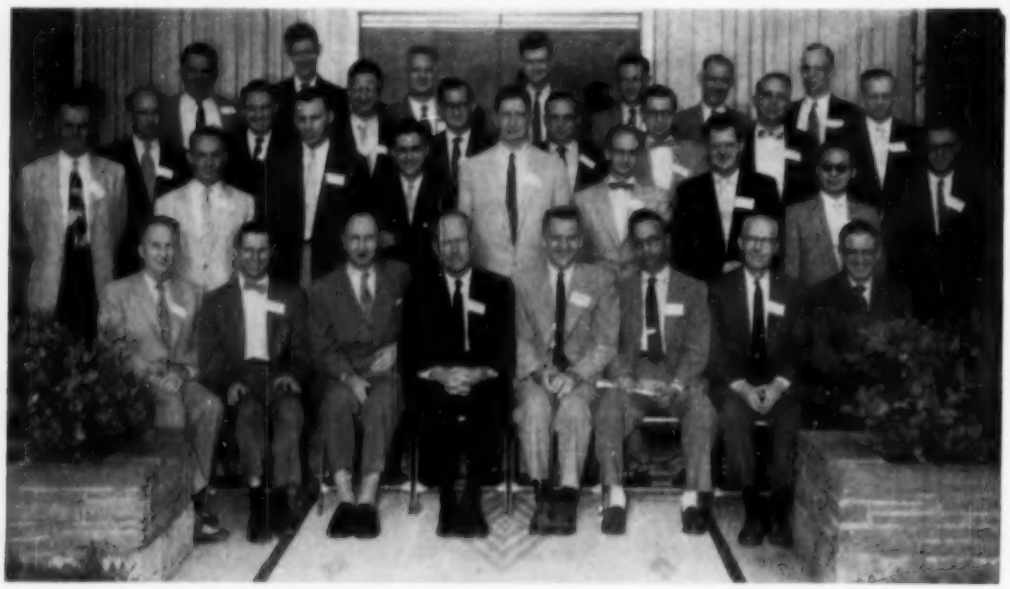
CORROSION: Seen recently at International Nickel Company's Kure Beach (N.C.) beach-side atmospheric corrosion test station, members of chemical industry representatives group making annual examination of test specimen status. Specimens include coated, welded, as well as solid metal and alloy pieces.

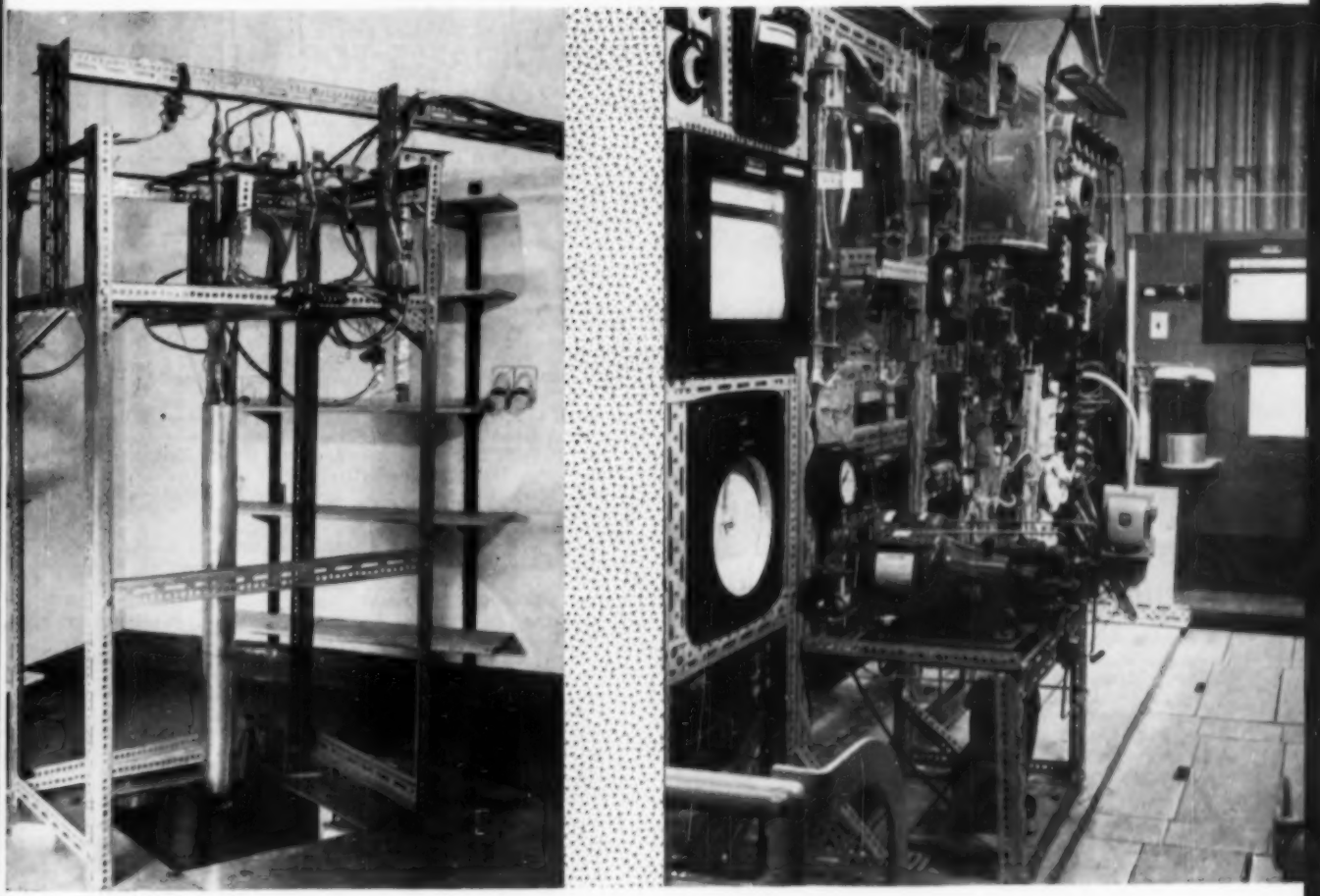


MULTIPLE-POURING TECHNIQUE for large foundations is demonstrated with Kaiser Steel Corp.'s 2,200 cubic yard pour of foundations for the mill's fourth blast furnace. Of interest to project engineers—time, seven hours, seven minutes.

INDUSTRY-SPONSORED SCHOOL

These 32 participants attended the Industry Sponsored School for engineering teachers held by the Lummus Co. (N.Y.) in Houston, Texas, under sponsorship of A.I.Ch.E. Coming from the Univ. of Texas, Texas A&M, Lamar State Coll. of Tech., La. Polytechnic, Rice Inst., Tulane, and the Univ. of Houston, they heard a detailed, comprehensive, day-long program on "Development of a Project From Inquiry to Acceptance by Customer."





RADIATION PROCESSING—PETROLEUM

Chemical flow reactor at Univ. of Mich.'s Phoenix Memorial Laboratory simulates actual petroleum refinery processing in study of effect of radiation superimposed on usual pressure-temperature-catalysis systems that have worked out in practice. With a pressure range of 0-3,000 pounds, and a temperature range of 0-1,300° F., this portable plant "model" has been used to study the possibilities of chemical processing of a wide range of hydrocarbons by radiation. On the right, behind concrete shielding, are the instrument control, reactant feed product handling, and the analytical systems. On the left is the actual chemical reactor assembly behind concrete shield, in position to have the radiation source brought up from the well to surround it. Source is MTR fuel element and cobalt-60. The entire assembly is constructed on an "erector set" type of framework. Similar rigs are presumed to be planned, or in use, by various refining research groups.



WORLD-RENOWNED Ziegler process inventor, Dr. Karl Ziegler (second from left) inspects new Hercules low pressure polyethylene plant using his process. With him (l. to r.): D. Bruce, E. Jennings, and president A. E. Forster of Hercules Powder Co.

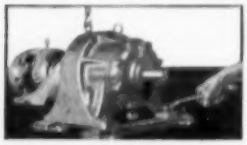


INITIAL PRODUCTION OF BUTADIENE begins at Firestone Tire & Rubber's Orange, Tex., plant as plant manager W. A. Wilson turns valve to start 40,000 ton plant.

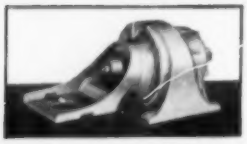


Designed to meet J.I.C. Specifications

In one compact power package a high-speed NEMA foot-mounted motor and a low-speed, double reduction gear transmission. Motor change in minutes! And with U. S. Motomount Syncrogear, the change is not limited to the type motor being replaced! If *you* carry a spare motor inventory, here is real flexibility and quick-change. U. S. Uniclosed, Totally-Enclosed, or Explosion-Proof motors of the same NEMA dimensions and ratings may be used to meet changing requirements. Available in h.p. ratings 1 to 30. U. S. Motomount Syncrogear has solid shank ever-tight pinion, friction-free oil seal, thru-hardened gears—many advanced features for longest life.



◀ **MOUNTS LIKE AN INTEGRAL UNIT, FOR INHERENT ALIGNMENT** . . . Both units of the U. S. Motomount Syncrogear have rugged, pyramidal base construction — made-to-match pyramids to hold motor and mount aligned for life—factory alignment PLUS centralized responsibility for manufacture of both components.



◀ **CAST IRON FOR ALL EXTERNAL PARTS** . . . For tough, industrial duty! Besides providing structural stability, cast iron protects against corrosive elements. All castings normalized for permanent retention of precision machining.



◀ **TAKES THE NEW RE-RATED NEMA MOTORS** . . . U. S. Motomount Syncrogear takes the re-rated NEMA motors in the new sizes. The wide range thus acceptable enables you to reduce spare motor inventory!

U.S. Electrical MOTORS (US MOTORS)

MAIL COUPON NOW ▼

U. S. ELECTRICAL MOTORS, Inc. CEP-7
P. O. Box 2058, Los Angeles 54, Calif., or Milford, Conn.
☐ *Request Full Information about Motomount Syncrogear*

NAME _____

COMPANY _____

ADDRESS _____

CITY _____ ZONE ___ STATE _____

CANDIDATES FOR MEMBERSHIP IN A. I. Ch. E.

The following is a list of candidates for the designated grades of membership in A.I.Ch.E. recommended for election by the Committee on Admissions.

These names are listed in accordance with Article III, Section 8 of the Constitution of A.I.Ch.E.

Objections to the election of any of these candidates from Members and Associate Members will receive careful consideration if received before August 15, 1957, at the office of the Secretary, A.I.Ch.E., 25 West 45th Street, New York 36, N. Y.

Member

Anderson, B. J., *Tuscola, Ill.*
Armstrong, Robert J., *Wilmington, Del.*
Bond, Rolston L., *College Park, Ga.*
Callanan, John P., *Pasadena, Md.*
Clancy, Gerald M., *West Covina, Calif.*
Collins, Henry W., *Kingsport, Tenn.*
Collins, Lathan H., Jr., *Baton Rouge, La.*
Crocker, Burton B., *St. Louis, Mo.*
Crownover, Ira G., *Kingsville, Texas*
Duren, James B., *Corpus Christi, Texas*
Eckenfelder, W. Wesley, Jr., *Tenafly, N. J.*
Fletcher, H. J., *Midland, Michigan*
Freed, Myron S., *East Hartford, Conn.*
Golladay, Ralph J., *Waynesboro, Va.*
Graham, James J., *The Hague, Holland*
Haas, John R., *St. Albans, W. Va.*
Harmon, William S., *Edgewood, Md.*
Herrick, Carlyle S., *Schenectady, N. Y.*
Hester, Robert, *Fordtown, Tenn.*
Hornaday, G. F., *Marcus Hook, Pa.*
Huber, Harold E., Jr., *Louisville, Ky.*
Jarl, Carl B., *Kalamazoo, Mich.*
Kingman, Paul W., *Media, Pa.*
Knapp, B. L., *Baytown, Texas*
Lydy, Charles M., *Torrance, California*
Marshall, Robert H., *Houston, Texas*
McCardell, William M., *Houston, Texas*
Miller, Thomas W., *Christiansburg, Va.*
Muller, Joseph M., *Pittsburgh, Pa.*
Myers, Arthur F., *Louisville, Ky.*
Robinson, W. Hitchcock, *Melrose, N. Y.*
Sarraf, Robert J., *Pittsburgh, Pa.*
Schaefer, Rodger L., *Decatur, Ala.*
Sheehan, John W., *Wood River, Ill.*
Sheridan, J. L., *Longview, Washington*
Slater, William L., *Whittier, Calif.*
Sledjeski, Edward W., *Euclid, Ohio*
Sloat, R. J., *Richland, Washington*
Stottmeister, Alvin P., *West Caldwell, N. J.*
Tully, T. J., *West Albany, N. Y.*
Weinman, Eugene A., *Wilmington, Del.*
Westfall, Paul R., *Coraopolis, Pa.*

Associate Member

Ally, Ahmed K., *Canoga Pk., Calif.*
Anderson, N. T., *Decatur, Ala.*
Armstrong, C. J., *Chattanooga, Tenn.*
Bacher, Joel, H., *Bronx, New York*
Bailey, Lawrence F. W., *Orillia, Ontario, Canada*
Beaudine, Milton J., *Decatur, Ill.*
Begell, William, *New York, N. Y.*
Bocard, Joseph P., *New Albany, Ind.*
Braun, George F., *Philadelphia, Pa.*
Brinkley, Wyndham K., *Baytown, Texas*
Butler, James L., Jr., *Pittsburgh, Pa.*
Calamari, Edward C., *Charleroi, Pa.*
Castle, Donald R., *Monsanto, Ill.*
Chan, Fu-Ho, *Philadelphia, Pa.*
Cheng, Francisco, *Iowa City, Iowa*
Chubb, Paul A., *Philadelphia, Pa.*
Clark, W. C., *McGregor, Texas*
Coonan, Thomas G., *Monterey, Calif.*
Donaldson, Paul A., *China Lake, California*
Earley, Walter R., *Philadelphia, Pa.*
Eberhardt, W. R., *Decatur, Ala.*
Edmonson, R. E., *Freeport, Texas*
Elmore, Robert Ronald, *Oak Ridge, Tenn.*
Epstein, Ira G., *Pine Bluff, Ark.*
Eubanks, L. Stanley, *Texas City, Texas*
Fenton, Walter M., *Minneapolis, Minn.*
Fitzsimmons, John J. M., *Newport, R. I.*
Foster, Donald A., *Baytown, Texas*
Foster, Ronald S., *Freeport, Texas*
Gercke, R. H. J., *Canoga Pk., Calif.*
Gibson, Carl H., *Oak Ridge, Tenn.*
Glass, Werner, *Plainfield, N. J.*
Gorup, Ivan I., *Montreal, Que., Canada*
Hague, David R., *Minneapolis, Minn.*
Hanlon, J. Vincent, *Atlanta, Ga.*
Hargis, James Henry, *Maryville, Tenn.*
Heman, George H., *Detroit 3, Mich.*
Hill, W. E., *Baton Rouge, La.*
Himmelblau, David M., *Seattle, Washington*
Irwin, E. C., *Woodbury, N. J.*
Jameson, D. B., Jr., *Houston, Texas*
Jordan, Charles A., *Houston, Texas*
Keane, Thomas R., *Niagara Falls, N. Y.*
Kidd, Kenneth W., *Baltimore, Md.*
Kingsland, Schuyler, *Nitro, W. Va.*

News of the Field
FROM LOCAL SECTIONS

(*Continued from page* 138)

Said Maijgren: a personal investment program should have a long term objective—10 years or more—unless the age of the investor leaves no choice but yield. . . . **Rhode Island Section** (*J. L. Campanella*) held its annual Ladies Night in March and A. Delsesto, president of the Van Dell Jewelry Corp. of Providence, talked on modern jewelry design, a business that involves chemical engineer and chemist to a considerable extent. . . . **Western Massachusetts Section** (*R. T. Bogan*) heard about the highly charged subject of Controlled Thermo-Nuclear Reactions at its March meeting.

CANDIDATES

(*Continued*)

Klupar, James A., *Avon Lake, Ohio*
Lambert, John B., *Wilmington, Del.*
Lawrence, Frederick C., *Pasadena, Texas*
Luedeking, Robert, *Pullman, Washington*
Li, Kun, *Pittsburgh, Pa.*
Liedl, Jerry, *Mahtomedi, Minn.*
Lindenauer, A., *Hopewell, Va.*
Liu, David Ho-Feng, *Texas City, Texas*
Maass, Richard L., *Houston, Texas*
Mai, Klaus L., *Houston, Texas*
Meyer, William John, Jr., *Lansdale, Pa.*
Miller, Howard W., *Borger, Texas*
Moore, Joe F., *Houston, Texas*
Movics, Richard C., *Pomona, Calif.*
Paille, Edward B., *Baton Rouge, La.*
Patel, M. C., *Uganda, Africa*
Perona, Joseph J., *Oak Ridge, Tenn.*
Pincus, Betram, *New York City, N. Y.*
Pratt, Elroy J., *Baytown, Texas*
Price, A. Roy, *Port Neches, Texas*
Proskowitz, Seymour, *Midland, Texas*
Rao, Rama Kanth, *Ames, Iowa*
Raynolds, David W., Jr., *Kingsport, Tenn.*
Ross, Kenneth Eller, *Seattle, Washington*
Sample, Paul E., *Morgantown, W. Va.*
Satterwhite, Frank M., *Houston, Texas*
Savage, Hugh J., *Canoga Pk., Calif.*
Savage, James R., *Maplewood, Mo.*
Scaglione, Sam A., *Garfield Hts., Ohio*
Schoening, Pete, *Seattle, Washington*
Sheehan, Charles J., *Springfield, Mass.*
Sher, Neil C., *Pgh, Pa.*
Small, Francis H., *Charleston, W. Va.*
Snider, James W., *Oak Ridge, Tenn.*
Solhkhah, Edward, *Whiting, Ind.*
Speight, Charles F., Jr., *Hampton, Va.*
Strand, Clarence A., *Richland, Washington*
Sukkar, Joseph, *Tulsa, Okla.*
Thomas, K. T., *Kerala, South India*
Trimarke, C. Robert, *Louisville, Ky.*
Truebe, Carl W., *Claymont, Del.*
Vandenberg, Kenneth W., *Houston, Texas*
Veitch, John D., *Decatur, Ala.*
Vetter, Clarence J., Jr., *Joplin, Missouri*
Von Dohlen, Henry C., *Highland Pk., N. J.*
Weekman, Vern W., Jr., *Woodbury, N. J.*
Whatley, Charles W., *Decatur, Ala.*
Wheeler, Joe, *Houston, Texas*
Wood, Donald W., *Westfield, N. J.*
Work, Harold K., Jr., *Wilmington, Del.*
Yang, Charles P., *Houston, Texas*

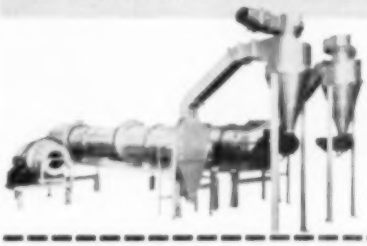
Affiliate Member

Mullarkey, Edward J., *New York, N. Y.*

When specifying Chemical Processing Equipment

Don't Buy "Guesswork" Designs!

Edw. Renneburg & Sons Co. designs and manufactures a complete line of Pilot Plant Equipment of the size, type, and materials (carbon steel, stainless or other alloys) to suit your requirements.



Three basic pilot units (Continuous Combination Ammoniator-Granulator, Dryer, and Cooler . . . complete with air-handling systems) for producing chemicals and chemical fertilizers. Designed and fabricated for a leading chemical company to be used in its Research and Development Center.



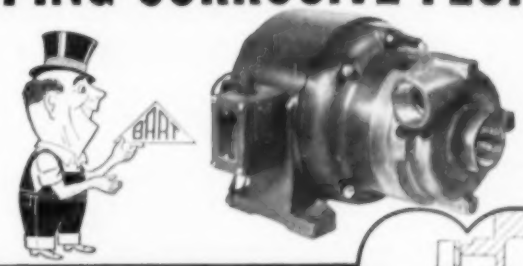
DehydrO-Mat (Patented) **Pilot Plant Dryer,** 21' long, is highly flexible in its operational capacities. One of these was recently sold to a South African Government to be used to institute a conservation program on agricultural waste.

Edw. Renneburg & Sons Co. has at your disposal a number of extremely versatile Pilot Plant Units to enable you to eliminate the guesswork from the design necessary to meet your production equipment requirements in the most economical manner. *Consult the Renneburg Engineers for details.*

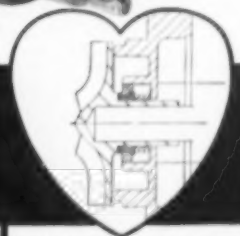
Edw. RENNEBURG & Sons Co.
BALTIMORE 24, MARTLAND, U. S. A.

now! greater ***safety*** *and* ***efficiency*** *in*

PUMPING CORROSIVE FLUIDS



BART
FLEX-SEAL
CENTRIFUGAL PUMPS



At last—a full line of pumps *specifically designed* to handle corrosive and abrasive fluids in the 1 to 80 GPM range, at heads to 75 feet.

No longer need you cut down bigger pumps in range and lose efficiency—or put up with undependable smaller pumps.

Bart pumps have fewer parts to wear or get out of order. Six models, each in two materials . . . Type 20 Stainless Steel or Hastelloy C . . . cover almost every application.

Write for catalog and performance curves.

Heart of the BART . . . the exclusive Flex-Seal!

Effectively minimizes a long-prevalent basic weakness of centrifugal pump design. Self-adjusting to wear. Needs no external lubrication. Carbon stator/ceramic seat, unexcelled for long wear—or zircon filled Teflon/work-hardened Type 20 Stainless Steel, for severest corrosive service.

BART MANUFACTURING CORP.
ELECTROFORMING · PIPE LINING & COATING · PLATERS · PUMPS · ENGINEERING DESIGN SERVICES
229 Main St., Belleville 9, New Jersey

people

Edgar B. Chiswell, formerly manager of process research and development for California Research Corp., has been appointed executive secretary of the newly-formed California Chemical Co. Chiswell is a director of the A.I.Ch.E.


Chiswell

Worcester Polytechnic Institute recently conferred the honorary degree of Doctor of Science on **Randolph H. Bretton,** associate professor of chemical engineering at Yale University. Bretton has specialized in the field of nuclear engineering.

Sidney S. Prince has been named chief engineer at the Yonkers, N. Y., plant of the U. S. Vitamin Corp. Before joining U. S. Vitamin in 1956, Prince was associated with Chemical Construction Corp. in New York.


Prince

Mathew M. Braidech, research director of the National Board of Fire Underwriters, has received Ohio State University's Benjamin G. Lamme Medal for 1957, given for "meritorious achievement in engineering or the technical arts." Braidech is nationally recognized as a leading authority in the fields of fire protection, disaster prevention, and industrial explosions.


Braidech

Before assuming his present position in 1945, Braidech was professor of chemical engineering at Case Institute of Technology, where he taught for nine years. He is the author of 72 publications in technical journals and numerous research reports.

Awards and citations received by Braidech include a merit citation from the National Defense Research Council, Office of Scientific Research and Development, presented in 1945 for wartime research on gas warfare and military water supplies.

James R. Gilbreath has been appointed assistant director of Argonne National Laboratory. Gilbreath will be involved in the administration of the Laboratory's research and development program.

Union Carbide announces appointment of **Robert M. Briney** as president of Haynes Stellite Co., a division of Union Carbide.

New members of the technical staff of the Atomic Energy Division of Phillips Petroleum Co. include **Roderick G. Beck, J. Wm. Codding,** and **Lawrence J. Harrison.**


Tillquist

Sinclair Chemicals announces appointment of **George E. Tillquist** as process engineer. Tillquist was previously with Sinclair Research Laboratories in Harvey, Ill.

Ronald B. Smith, vice-president of M. W. Kellogg, New York, has been named as director of technological activities of the A.S.M.E.

Charles B. Hunt has joined the Research and Development Department of Ethyl Corp. at Baton Rouge, La., as a chemical engineer.

George T. Collins will direct the operations of Pennsalt International Corp., subsidiary of Pennsalt Chemicals Corp. Collins joined Pennsalt in 1943 as a market research engineer.

Wilbur L. Nelson receives the 1957 Award of Merit of the American Association of Cost Engineers. Nelson has been professor of Chemical and Refinery Engineering at the University of Tulsa since 1930.


Nelson

E. J. Corell and **M. W. Jones** have formed a partnership to do engineering and consulting work in the heavy chemical and power fields. Offices of the new firm will be in Akron, Ohio.

Two nationally-known consultants, **J. A. Patterson** and **Edward W. Hopper,** have been retained by J. F. Pritchard & Co. to assist in the development of their newly-established Extractive Metallurgy Division.

CORRECTION

The item in *CEP* May, 1957 (page 150), regarding the Gordon Research Conferences was misleading. **Robert W. Schiessler** of Socony Mobil Laboratories will be chairman of the Board of Trustees this year, and **Raymond Stevens,** president of Arthur D. Little, will take over that office in 1958.

(Continued on page 146)

Investigate the **ARTISAN**

ENGINEERING AND MANUFACTURING APPROACH TO *YOUR* SPECIAL PROCESSING PROBLEMS

- ***Chemical Engineering* DESIGN.**
  A staff of qualified chemical engineers, *accustomed to working cooperatively* with the engineers and management of process manufacturing companies . . . specially trained men whose recognized achievements have resulted in their being retained as consultants on many process installations.
- ***Mechanical Engineering* DEVELOPMENT.**
  A complement of mechanical engineers who pool their specialized abilities in equipment design to *develop in detail the mechanical units* required to economically operate your specific chemical process.
- ***Facilities for* MANUFACTURING.**
  Integrated resources for fabrication, including modern shop equipment for heavy sheet metal forming, specialty welding, and all machinery operations.

REPRESENTATIVES:

Paul A. Chapman & Associates
Post Office Box 8205
Chattanooga, Tennessee
CHattanooga 6-5863

Paul A. Chapman & Associates
Post Office Box 787
Johnson City, Tennessee
JOhnson City 3113

Chemical Pump & Equipment Corp., 75 West Street
New York 6, New York
BOwling Green 9-7544

Chemical Pump & Equipment Corp., 712 State Tower Building
Syracuse, New York
SYracuse 3-4797

Chemical Pump & Equipment Corp. of Cleveland
11328 Euclid Avenue
Cleveland 6, Ohio
SWeetbriar 5-4900

James W. Conrad
1526 Denniston Avenue
Pittsburgh 17, Pa.
GRant 1-0550

The Hainge Company, Inc.
3518 Durness, Houston, Texas
MOnroe 7-2761

Jacobs Engineering Company
3018 East Foothill Boulevard
Pasadena 8, California
RYan 1-9373

Jacobs Engineering Company
600 Sixteenth Street
Oakland 12, California
TEmplebar 2-5391

W. L. Marple & Associates
Box No. 145
Plymouth Meeting, Pa.
TAylor 8-4278

John M. Marshall
2416 West Cary Street
Richmond, Virginia
Richmond 84-1603

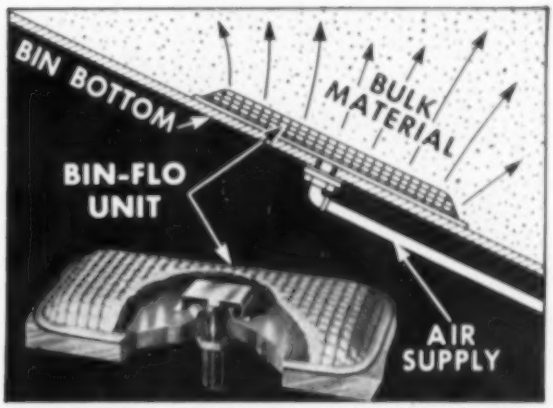
Patton Engineering Co., Inc.
2333 South Hanley Road
Saint Louis 17, Mo.
MIssion 7-0800

Schultz-Forster Associates, Inc.
4514 Main Street
Buffalo, New York
CIrcle 2227

Southeast Engineers, Inc.
1207 Comer Building
Birmingham, Alabama
Birmingham 3-8043

ARTISAN METAL PRODUCTS INC.
73 Pond Street, Waltham (Boston 54), Massachusetts
PROCESSING EQUIPMENT ***DESIGNED, DEVELOPED, MANUFACTURED***





BIN-FLO USES SMALL VOLUME OF AIR AT LOW PRESSURE

KEEPS BULK MATERIALS MOVING

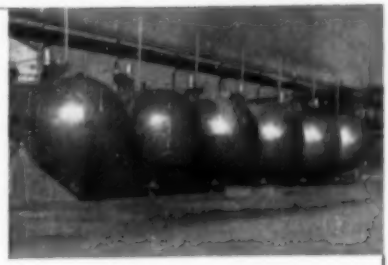
BIN-FLO units in bins, chutes, hoppers, etc., restore flow characteristics to dry, finely ground materials which tend to pack or bridge in storage. Types for all materials and conditions. No moving parts; simple installation; negligible operating cost; no maintenance cost.

BIN-DICATOR the original diaphragm-type bin level indicator. In successful use for over 20 years. **ROTO-BIN-DICATOR** new, motor-driven paddle type; excellent on bins under pressure or vacuum, and for general application. Also explosion-proof units, U.L. listed.

THE BIN-DICATOR CO.
13946-H Kercheval • Detroit 15, Mich.
Write for detailed literature or call VAlley 2-6952

WE SELL DIRECT • PHONE ORDERS COLLECT

WELDED ALUMINUM TANKS



• Welded aluminum tanks for storage, pressure vessels and processing equipment built to ASME Code specifications to meet all insurance requirements; pure aluminum tanks for hydrogen peroxide storage or other purposes. Conventional or special design tanks, shop built-up or field-erected, can be built to your specifications. Write for *Tank Talks*.

R. D. COLE MANUFACTURING CO. COLE NEWNAN, GEORGIA

Elevated Tanks, Pressure Vessels, Chemical and Processing Equipment from Aluminum, Stainless and Carbon Steel, Monel and Other Alloys.

Established 1854

R. D. COLE MANUFACTURING CO.
NEWNAN, GEORGIA



CHEMICAL ENGINEERS!

WHEN YOU NEED PRECISION — SPECIFY WILMAD PRECISION BORE TUBING!

- Whether the job you're working on is design, testing or processing, you get maximum precision when you specify Wilmad Precision Bore Tubing.
- Ideal for use in barometers, bearings, manometers, rotameter tubes, burettes, viscosimeters, and hundreds of other applications.
- Made in various shapes and sizes . . . square, rectangular, hexagonal and tapered. Special shapes to meet your requirements. Available in Pyrex Brand, Vycor Brand and most of the electronic glasses.
- Send today for detailed catalog.

Wilmad
GLASS COMPANY, INC.
LANDISVILLE, N. J.

"SERV-RITE"
THERMOCOUPLE
HEAD



the head that's ahead in every way . . .

This new "Serv-Rite" thermocouple head is actually small enough to be held comfortably in the palm of your hand. But size is only one of the many features that make this thermocouple head really extraordinary. It is loaded with installation and service conveniences that any user of thermocouples will appreciate at once.

The body is of malleable iron, cadmium plated for durability. A new type friction lock assures easy removal or tightening of the cap — a quarter turn does it. An asbestos gasket makes the head dirt- and moisture-proof. With a choice of ½", ¾", or 1" IPS opening for the protecting tube, you can standardize on one style head.

The connector block is of a material especially selected to withstand, without damage, temperatures up to 900° F. in continuous service. Improvements over the conventional type of inserts greatly simplify the making of the lead wire connections. The complete thermocouple element, including connector block, can be easily withdrawn for inspection.

Install a "Serv-Rite" thermocouple head and see for yourself how much better it really is.

Write for complete details

4603

GORDON SERVICE

CLAUD S. GORDON CO.

Manufacturers • Engineers • Distributors

Thermocouples & Accessories • Temperature Control Instruments • Industrial Furnaces & Ovens Metallurgical Testing Machines

631 West 30th Street, Chicago 16, Illinois
2003 Hamilton Avenue, Cleveland 14, Ohio

people

R. E. Workman, manager of the Chemical Division of the Goodyear International Corp., has been awarded a Sloan Fellowship for participation in the executive development program at M.I.T. Workman has been with Goodyear since 1942.



Workman

Arthur W. Carpenter, who retired from B. F. Goodrich in March, 1955, has been selected by the Division of Rubber Chemistry, A.C.S., to receive the Charles Goodyear medal for outstanding contributions to rubber science and technology.

Southwest Research Institute, San Antonio, Texas, names **Eugene P. Whitlow** as chairman of their Department of Chemistry and Chemical Engineering. Whitlow is the author of several articles in the field of refrigeration engineering.

The honorary degree of Doctor of Engineering has been awarded by the Polytechnic Institute of Brooklyn to **Charles A. Thomas,** president of the Monsanto Chemical Co.



Thomas

Fansteel Metallurgical Corp. announces appointment of **Samuel A. Wilson** as technical assistant to Rea Winchester, vice-president and manager of the company's Metals and Chemicals Division. It is contemplated that Wilson will later be transferred to Fansteel's new tantalum-columbium plant at Muskogee, Oklahoma.

Donald O. Swan, since September, 1955, general manager of Esso's Baton Rouge refinery, has been named assistant general manager of the company's Manufacturing Department. In his new post, Swan will headquarter in the company's New York offices.

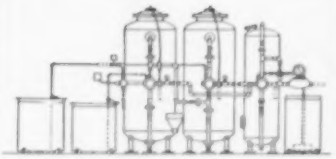


Swan

Clifford F. Rassweiler, president-elect of the American Chemical Society and vice-chairman of the Board, Johns-Manville Corp., named to receive 1957 Honor Scroll of the New York Chapter of the American Institute of Chemists.

(*Continued on page* 148)

ILLCO-WAY
ionXchange

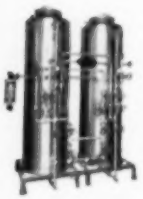


GET H_2O ONLY

In those processes where chemically-pure water is desired, the most economical way to obtain it is often by de-ionization. Current ionXchange practice provides an effluent which is chemically the equivalent of that obtained by multiple distillation.

ELIMINATE ALL DISSOLVED SOLIDS

Starting with water containing various dissolved solids such as calcium sulfate, magnesium carbonate, silica, etc., one form or another of ionXchange can be employed to eliminate ALL of these solids in the resultant purified water. ***We have been designing and building practical equipment to accomplish such results ever since the enabling resins first became available.*** **Tell us your needs, and let us see what we can do . . .**



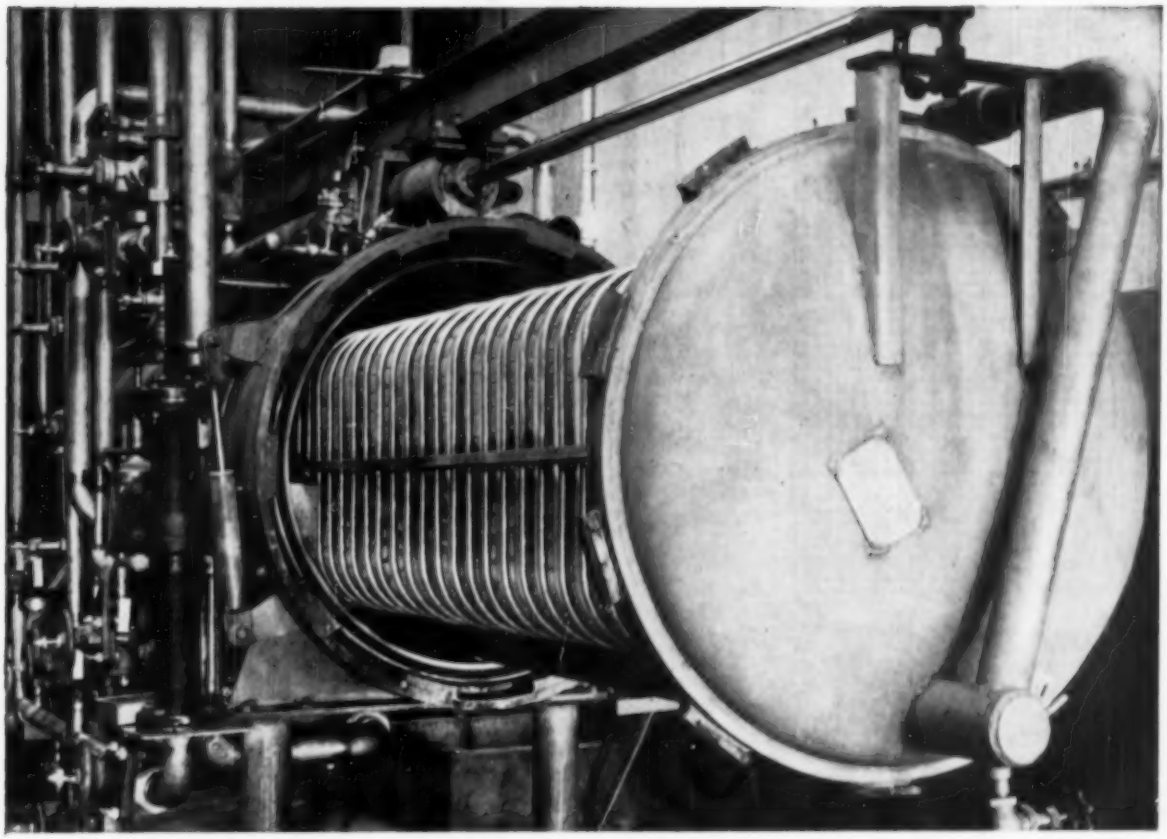
ILLINOIS WATER TREATMENT CO.

ionXchange

ILLCO-WAY

**840 CEDAR ST.
ROCKFORD,
ILLINOIS**

NEW YORK OFFICE: 141 E. 44TH ST., NEW YORK 17, N. Y.
CANADIAN DIST. PUMPS & SOFTENERS, LTD. LONDON, ONT.



How Industrial Filter gets the profit out of fruit juice "Tank Bottoms"

The trouble with natural fluids is their variability—not only differences in batches but their tendency to stratify in storage. The latter was the problem in handling fruit juice at an eastern plant—the bottom layers in tanks were heavy with particles of valuable crystallized sugar that were lost in clarification. With their new Industrial filter system they extract the sugar at a handsome profit that paid for the system in a few months.

Industrial's Horizontal Filter clarifies juice and recovers sugar in one continuous operation. The filter is first pre-coated and clarification established. The juice is then flowing from the storage tank thru the filter and on to the processing lines. After the filter leaves have built up the maximum coating, the filter is blown dry and a mixture of water and air is injected under pressure. The water dissolves the fruit sugar and is continuously filtered out until the sugar content drops below 2% of soluble solids. The filter is then emptied, opened and the cake is recovered. Most Industrial Horizontal Filters have mechanical shakers that drop the cake directly into a truck for fast clean recovery of solids.

Industrial engineered filtration is not only cost saving... it's downright profitable! Besides the lucrative recovery of solids, this up-to-date unit operates at a high filtration rate, it requires only one man to run it, it eliminates the buying and washing of filter press cloths, and its all-around efficiency requires less filter aid.

Industrial produces all types of filters . . . Horizontal, Vertical, Tubular, Hydra Shoe . . . and can *recommend, without partiality, a filter most suitable to your particular requirements.* A great variety of cost-saving optional features are available and almost all Industrial Filters *are adaptable to complete automation.* Intelligently selected, soundly engineered filters can pay for themselves in a surprisingly short time.



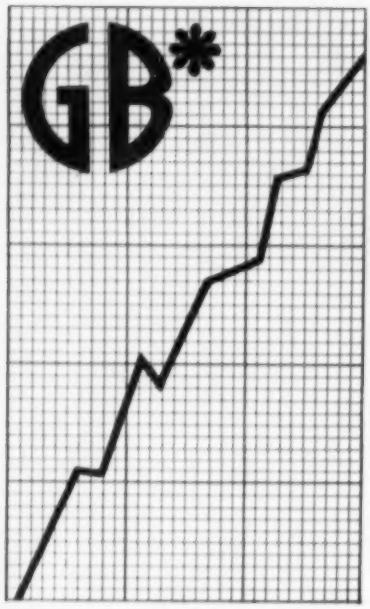
Write for Bulletin NH-122, a complete description of Industrial's Horizontal Filters.

Industrial

INDUSTRIAL

FILTER & PUMP MFG. COMPANY

5910 OGDEN AVENUE • CHICAGO 50, ILL.



*means
Good Business

For over half a century Good Business has been represented by Goslin-Birmingham, offering world wide service to users of mechanical and heat transfer equipment, including custom designing and foundry service.



G-B engineers are at your service at any time to discuss your processing problems.

GB GOSLIN-BIRMINGHAM MANUFACTURING CO., INC.
BIRMINGHAM, ALABAMA

people

Julian A. Rogers becomes vice-president in charge of production for the Best Fertilizer Co. Rogers was formerly with W. R. Grace & Co., where he was head of the Manufacturing Department of Grace's polyethylene plant in Baton Rouge, La.



Rogers

Harold Torgersen, associate dean of N. Y. University College of Engineering, appointed dean of School of Engineering at University of Connecticut. Among other duties, Torgersen will supervise development of new Chemical Engineering Department.

Raybestos-Manhattan, Inc., names **Edward V. Huda** to direct research and development for their Adhesives Department.

Davidson-Kennedy Associates Co. announce appointment of **H. M. Betzig** as vice-president, engineering. Prior to joining Davidson - Kennedy, Betzig was chief engineer for Pollak and Skan, Inc.



Betzig

Phillip C. Davis promoted to supervisor of process development of the Research and Development Department of Ethyl Corp. at Baton Rouge, La. Davis joined Ethyl in 1952 as a process design engineer.

Harry B. Warner, vice-president for development of B. F. Goodrich Chemical Co., named recipient of the "Outstanding Alumnus Award" presented annually by Texnikoi, College of Engineering organization at Ohio State University.



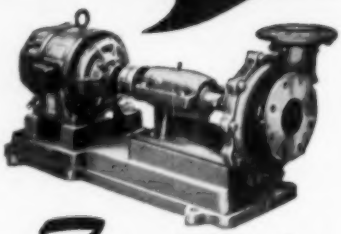
Belcher

New vice-president of Bowen Engineering is **D. W. Belcher.** Belcher joined Bowen in 1948 as functional design engineer and in 1954 was advanced to chief engineer.

Louis D. Scott appointed production projects manager of Chemstrand Corp.'s Acrilan plant organization. Scott will be succeeded as Acrilan plant manufacturing superintendent by **Norman C. Sidebotham.**

(Continued on page 154)

Custom-built for EFFICIENT DEPENDABLE SERVICE



Frederick
SSV PUMPS

Enclosed Impeller and Open Impeller Types

You're sure of maximum service and output with minimum maintenance or production down time with Frederick SSV Centrifugal Pumps because each pump is custom-made to fit your particular operation—whatever the consistency or type of liquid you're moving.

SSV PUMP FEATURES

- **Pump sizes from 1" to 4" discharge openings.**
- **Pump capacities from 30 up to 700 U.S. GPM.**
- **Heads from 30 up to 220 feet.**
- **Pumps speeds can be varied to suit the driving media and operating conditions.**

CONSTRUCTION ADVANTAGES

Pump casings are vertically split for easy accessibility. Mounted on a swivel to permit placing discharge in any desirable position. Pump openings, both suction and discharge, flanged to permit easier connection and disconnecting to joints. One-piece impellers, securely attached to shaft by stout key and lock nut, or threaded, give long service. Pump bearings mounted in sturdy frame horizontally split for easier accessibility. Extra long stuffing box provides for oversize stuffing. Mechanical seal also available for minimum leakage. Pump coupling flexible for direct connection to drivers or can be arranged for belt drive. Pump speed, pump openings, etc. are selected to suit your particular requirements.

Write for Bulletin No. 107

FREDERICK PUMPS

FREDERICK IRON AND STEEL, INC.
FREDERICK *Est. 1890* MARYLAND

CLASSIFIED SECTION

Address Replies to Box Number Care of CHEMICAL ENGINEERING PROGRESS

SITUATIONS OPEN

BECHTEL

NEW YORK
OR
SAN FRANCISCO

Offers immediate long range opportunities for

ENGINEERS

Chemical—Mechanical

Process or project experience in refinery, petrochemical or chemical fields.

Liberal relocation allowances for you and your family.

Send resume to
Manager of Employment & Placement
Industrial Relations Division

BECHTEL
Engineers and World-Wide Builders for Industry
220 Bush Street
SAN FRANCISCO 4, CALIF.

Recruiting Offices in New York, Houston, San Francisco and Los Angeles

---

CHEMICAL ENGINEERS

Opportunities in **Research and Development**

. . . . . Equipment and Process Design
. . . . . Process development work
. . . . . Product improvement studies
. . . . . New product development

American Viscose Corporation is a chemical process company that manufactures synthetic fibers, films, plastics, and related chemicals.

Openings are technically challenging and offer good advancement possibilities. Location is in Suburban Philadelphia.

AVISCO

Applications are invited from B.S. and M.S. chemical engineers with 1-8 years of experience.

Send resumes to:
Recruitment Director
AMERICAN VISCOSE CORPORATION
1617 Pennsylvania Boulevard
Philadelphia 3, Pennsylvania

INDUSTRIAL HYGIENISTS

MEDICAL RESEARCH DIVISION REQUIRES TWO YOUNG INDUSTRIAL HYGIENISTS

Applicants should be under 30 years of age with degrees in chemical engineering, sanitary engineering or chemistry. Graduate training in industrial hygiene is desirable, but not required.

GENERAL AREA OF WORK

As a member of a team, will work in an advisory capacity in performing industrial hygiene studies for affiliates of Standard Oil Company (N.J.) including:

1. Basic studies for evaluation and control of environmental health problems associated with producing, refining, manufacture of petrochemicals and in marketing.
2. Special studies of individual problems in terms of evaluation and control methods.
3. Industrial hygiene research in areas of instrumentation, analytical methods, study techniques, ventilation and other methods of control.

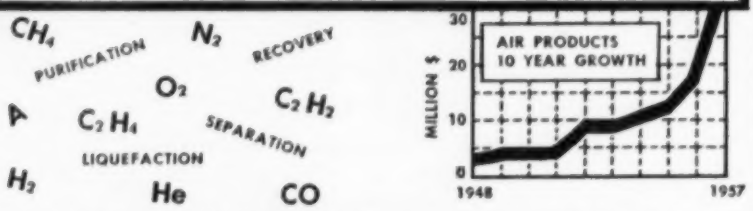
Excellent library and technical facilities and liberal publication policies. Advancement unlimited except by ablity. Starting salary commensurate with experience and ability.

Give full details of education, experience, desired salary, availability date and references. All inquiries will be considered promptly and held confidential. Address replies to:

ESSO RESEARCH AND ENGINEERING COMPANY
(Chief Technical Affiliate—Standard Oil Company (New Jersey)
Esso Research Center
Employee Relations-C
P. O. BOX 51 • LINDEN, N. J.

CHEMICAL & MECHANICAL ENGINEERS

are offered opportunity to advance professionally in diversified growth company



LOW TEMPERATURE PROCESSING

The Company is the leader in the engineering, design, manufacture and construction of plants and systems for the separation of gases such as Oxygen, Nitrogen, Carbon Monoxide, Hydrogen and other low boiling building blocks of the chemical industry. We must expand the entire organization to meet the increasing demands of the steel, metallurgical and chemical industries, and for national defense.



Selected Assignments

- PROCESS DESIGN ENGINEERS
- RESEARCH & DEVELOPMENT ENGINEERS
- PROJECT ENGINEERS
- ESTIMATING & ECONOMIC EVALUATION ENGINEERS
- MECHANICAL ENGINEERS
- DESIGN ENGINEERS
- CONSTRUCTION ENGINEERS
- FIELD OPERATIONS MANAGER
- OPERATING SUPERINTENDENT
- MANUFACTURING & PROCESS ENGINEER
- SALES ENGINEERS

AIR PRODUCTS, INC., situated in Eastern Pennsylvania at the foothills of the lovely Pocono Mountains, with ready access to three fine universities as well as other cultural and recreational facilities, offers you . . .

1. **High professional salary scale.**
2. **Company paid advanced educational program.**
3. **Unusual medical and life insurance program.**
4. **Bonus and profit sharing opportunities.**
5. **Fine retirement plan.**

At AIR PRODUCTS you will work with recognized leaders in the industry.

Send resume in confidence to Mr. E. J. Strobel

Air Products

. . . INCORPORATED

P.O. Box 538 **Allentown, Pa.**

CHEMICAL PROJECT ENGINEER

Minimum BS chemical engineering degree and 5 years' experience in chemical industry, to design organic chemical plants from development data. Responsible for over-all design right through start-up. Salary open. Send resume to Employment Office, E. R. Squibb & Sons, Div. of Olin Mathieson Chemical Corporation, New Brunswick, New Jersey.

ENGINEERS

DESIGN

PROCESS

PROJECT

•

Established Engineering and Construction Firm serving the Gas, Petro-Chemical and Power Industries has several openings for capable engineers. Our new air-conditioned building is located in the famous Country Club Plaza and adjacent to excellent residential district. Should you desire a challenging position that offers advancement and compensation in recognition of your talents, please send complete resume to Mr. Hunter.

(All inquiries kept confidential)

J. F. PRITCHARD & CO.
4625 Roanoke Parkway
Kansas City, Missouri

PETROLEUM REFINERY CHEMICAL ENGINEERS

Positions involving technical service and consulting type work for petroleum refineries are available in Refinery Technology Division. Chemical engineers working in refinery process engineering or operation and economic analysis are well qualified for these positions. Positions offer a wide variety of work assignments in an expanding technical activity that works with sales, research, refinery, and company management problems. Positions also afford opportunities for industry-wide contacts with refining and process companies and for using initiative and individual expression to increase responsibility. Location in a Detroit suburb offers ideal professional environment with a choice of city or suburban living. For more particulars, send name and address to:

Personnel Manager,
ETHYL CORPORATION
1600 West 8 Mile Road
Ferndale 20, Michigan

CHEMICAL ENGINEERS

Large manufacturer of organic chemicals, located in the East, has several openings for Chemical Engineers with a B. S. or M.S. degree, having 5-10 years experience in process development, production or pilot plant studies.

Please send resume.
All replies confidential.

BOX I-7



Destination:

Leadership

Every week, scientists and engineers from all over the country arrive at Argonne to begin their work at this center of research and development studies in nuclear science. They have selected Argonne, recognizing the value of an organization whose interests include physics, chemistry, biology, metallurgy, applied mathematics and electronics; as well as nuclear, chemical, and mechanical engineering.

Argonne

NATIONAL LABORATORY

Operated by the University of Chicago under a contract with the United States Atomic Energy Commission

Inquiries Invited

METALLURGISTS • CHEMICAL ENGINEERS
MATHEMATICIANS • PHYSICISTS • CHEMISTS
METALLURGICAL ENGINEERS • MECHANICAL ENGINEERS
ELECTRICAL ENGINEERS • HEALTH PHYSICISTS
PLANT ENGINEERS • SAFETY ENGINEERS
INDUSTRIAL HYGIENISTS

PROFESSIONAL PERSONNEL OFFICE
P. O. BOX 299 • LEMONT, ILLINOIS

ORO ANNOUNCES CHALLENGING OPENINGS IN

OPERATIONS RESEARCH

Operations research is a fast growing and practical science attracting some of the best brains in the country. Its future is unlimited. If you want to join a group of pioneers in this new and exciting field, we invite you to investigate the openings available on our staff. Men required must be capable of thinking creatively, must be able to work on their own *and* within a group, and must be keenly interested in finding answers to practical problems.

ON OUR PART WE OFFER:

1. A record of experience in operations research, out-distanced by perhaps no other organization.

2. A scrupulously maintained professional approach and atmosphere.

3. The team approach to problem solving. On each team are representatives of varied disciplines—sometimes three, occasionally as many as a dozen.

4. Fully equipped digital and analog computing facilities.

5. ORO occupies several buildings in Chevy Chase, Maryland, one of America's most attractive suburbs. Pleasant homes and apartments in all price ranges are available for rental or purchase. Schools are excellent. Downtown Washington, D. C., with its many cultural and recreational advantages is but a 20-minute drive.

6. Favorably competitive salaries and benefits, extensive educational programs, unexcelled leave policy.

FOR DETAILED INFORMATION, WRITE:
Dr. L. F. Hanson

OPERATIONS RESEARCH OFFICE
ORO The Johns Hopkins University
7100 CONNECTICUT AVENUE
CHEVY CHASE 15, MARYLAND

Chemical Engineers

For polymer pilot plant operations, in our Cincinnati research division. Will progress into specialized engineering studies, pilot plant design, engineering scopes and economic evaluations.

Excellent opportunity for aggressive men with one to three years experience in one or more of the following fields: Automatic Instrumentation, Pilot Plant Operation, High pressure Equipment, Polymer Evaluation and Equipment Design.

Submit resume to Industrial Relations Department.

U.S. INDUSTRIAL CHEMICALS CO.
Division of
National Distillers & Chemical Corp.
99 PARK AVE. • NEW YORK, N.Y.

CHEMICAL ENGINEER
OR
PETROLEUM ENGINEER

M.S. or PH.D.

To direct product research on oil and gas field equipment. Engineer should have experience in natural gas or petroleum processing and possess a good background in thermodynamics.

This important position offers excellent opportunity for professional advancement for an ambitious, creative engineer.

Please send complete information and photograph to **Orval W. Groves, Employment Supervisor,** at address shown below:

BUTLER MANUFACTURING COMPANY
7400 East 13th Street
Kansas City 26, Missouri

MARKET RESEARCH ECONOMIC EVALUATION

Position open in expanding Marketing Group of Research and Commercial Development Laboratory.

Duties include preparation, evaluation, interpretation and presentation of business opportunities and product studies to Management for decisions and action. Some travel required. Headquarters—Charleston, West Virginia.

Training in chemistry, chemical engineering or marketing and some experience in the chemical industry required. Experience in market research, economic evaluation, technical service or sales desirable.

Contact Manager of Laboratory Services
Research and Development Laboratories
Westvaco Chlor-Alkali Division
Food Machinery and Chemical Corp.
South Charleston, West Virginia

SITUATIONS WANTED

A.I.Ch.E. Members

PRODUCTION MANAGEMENT ENGINEERING—M.Ch.E. Fifteen years' experience in chemical food processing and aerosol packaging plants. Plant manager, process engineer, process evaluation and development, production supervision. Seeking responsible position in production management. Present salary $11,000. Box 5-7.

CHEMICAL ENGINEER—Ph.D. Ten years' responsible experience process development, development-production-liaison, and plant start-ups. Publications and honoraries. Desire responsible position with definite opportunity for advancement to administrative or management level. Box 6-7.

CHEMICAL ENGINEER—Age 30. Completing doctorate. Seven years' experience. Nuclear fuels, high temp. molten-salt technology, heavy inorganics, dyes, detergents. Research, development, pilot plant, cost estimating, process evaluation. Supervisory experience. Married, veteran. "Q" clearance. Box 8-7.

CHEMICAL ENGINEER—B.Ch.E. 1953, Age 26, family. M.Ch.E. completion—June, 1958—honors. Desire vicinity metropolitan New York. Three and one-half years' R and D. Pilot plant design, construction, instrumentation. Cost analyses, and process design. Supervisory experience, patent application. Box 9-7.

CHEMICAL ENGINEER—B.S.Ch.E. 1951. Six years' varied experience in development, production, process studies, process design and start-up in the petro-chemical and plastic fields. Midwest location preferred. Box11-7.

CHEMICAL ENGINEER—D.E.S., 34. Eight years' experience in petroleum and mineral industries. Engineering research, pilot plant. Currently in charge of economics evaluation group. Patents, publications, honoraries, professional society, A.E.C. clearance. Desire process development supervisory position with growing small, medium or newly founded subsidiary company. Box 12-7.

COST ENGINEER—Seek responsible post. Chemical engineering, estimating, cost control supervising background. Nineteen years with major chemical company. Writing ability. B.M.E. degree. Box 13-7.

CHEMICAL ENGINEER—B.Ch.E., Brooklyn Polytechnic Institute. Two years' experience in process research and development. Exc. advancement record. Married; 22; "Q" clearance. Desire position New York metropolitan area—process development, pilot plant or production. Box 14-7.

DEVELOPMENT SUPERVISOR—Top management potential. M.S. in Chemical Engineering. Business Administration training. Outstanding contribution in ion exchange, water and waste treatment, nuclear power reactors. Honors, publications. Primary requisite—more responsibility with commensurate rewards. Box 16-7.

RESIN TECHNOLOGIST — CORROSION ENGINEER—M.Ch.E., Brooklyn Polytechnic Institute. Twelve years' process development, application and formulation of phenolics, epoxies, polyesters, vinyls and polyurethanes. North Jersey or East preferred. Minimum salary $10,000. Box 18-7.

CHIEF PROCESS DESIGN ENGINEER—M.Sc. Desire to make contract for consulting work with company planning expansion, new projects, or engineering economic studies. Twenty years' detailed experience with major oil companies and contractors. Skilled in oil refining, gas processing of all kinds, natural gasoline, petrochemicals such as ethylene, ammonia, and hydrogen, coal conversion and cost estimating. Skilled in plant expansion with minimum equipment additions. Box 19-7.

CHEMICAL ENGINEER—B.S.Ch.E. 1940. Eight years' titanium dioxide pigment manufacture, three years' phosphate fertilizers. Considerable experience in plant start-up and process trouble-shooting, in production supervision and staff engineering positions. Southeast or midwest location preferable. Box 20-7.

Chemical Engineers BS, MS, PhD

for

Development

Engineering

Increased activity in the chemical fiber field creates the need for graduate engineers with up to 10 years experience in process development, production or process engineering.

These positions demand engineers capable of performing independent work on problems including the development of new fiber manufacturing processes and pilot plant operation.

Celanese's new textile headquarters in lovely Charlotte, N.C. can provide the very best facilities for the full utilization of engineering talent. Personal and professional progress is encouraged . . . and the advancement opportunities are available due to the planned expansion program.

If your background qualifies you for one of these newly created positions, send a resume to L. H. Hitchens. Please include initial salary requirements.

Celanese CORPORATION OF AMERICA

P.O. Box 1414 Charlotte, North Carolina

CHEMICAL ENGINEERS
PROCESS ENGINEERING

Young men with advanced degrees in chemical engineering or at least three years' experience in process design of oil refining or chemical manufacturing facilities. Opportunities directly concerned with evaluation of research projects in the petroleum and chemical fields and design of new process units for Shell Oil Company and Shell Chemical Corporation. Located in the San Francisco Bay Area. Write giving education, experience, and personal history to Employment Supervisor.

SHELL DEVELOPMENT COMPANY

Emeryville 8 • California

CHEMICAL ENGINEER—Ph.D.—Desire academic position in an accredited chemical engineering department with opportunities for contractual and consulting work. Ten years' responsible experience in process development and specialized experience in spray drying and crystallization. Publications and honoraries. Box 10-7.

Nonmember

CHEMICAL ENGINEER—Near Ph.D. with five years' responsible experience supervision of process research, development, design and cost estimation. "Q" clearance. Desire responsible position in process design or development with advancement potential and security. Prefer New York area, but not necessary. Age 32, married, family. Box 15-7.

CLASSIFIED SECTION RATES

Advertisements in the Classified Section are payable in advance at 20¢ a word, with a minimum of four lines accepted. Box number counts as two words. Advertisements average about six words a line. Members of the American Institute of Chemical Engineers in good standing are allowed one six-line Situation Wanted insertion (about 36 words) free of charge a year. Members may enter more than one insertion at half rates. Prospective employers and employees in using the Classified Section agree that all communications will be acknowledged; the service is made available on that condition. Answers to advertisements should be addressed to the box number, Classified Section, Chemical Engineering Progress, 25 West 45th Street, New York 36, N. Y. Telephone COlumbus 5-7330. Advertisements for this section should be in the editorial offices the 15th of the month preceding publication.

DAVIS-Built Precision **MIXER**



100 lbs. to 8,000 lbs. per Batch!

Gives 100% uniform mix in minutes—Dry Powders, chemicals, pharmaceuticals, vitamins, dry and molasses feeds, self-rising flour and meal, cold shortening, fertilizers, insecticides. Abolishes guesswork and downtime. Modestly priced. Write for literature.

H. C. DAVIS SONS'
Mill Machinery Co.
Box C-185
Bonner Springs, Kansas
Established 1894

SIMPLYTROL AUTOMATIC PYROMETERS
For Control of Temperature



10 standard ranges from −200° to +3000° F.

Accuracy 2% (limit of calibration error).

Sensitivity 4 ohms per millivolt.

Cat. No. 4335, size 10" x 6" x 7". Range 0/1000°F, 0/500°C. $135.00

Thermocouple-type automatic pyrometer for controlling temperature in furnaces or ovens and manufacturing processes. Leads between Simplytrol and its thermocouple sensing element may be up to 100 feet or more depending on temperature range and lead wire resistance. Load relay, 5 amperes S.P.D.T. Optional heavy duty relays to 40 A. Either AUTOMATIC control or LIMIT shutoff. An automatic Simplytrol turns heat on and off to hold required temperature. Proportioning effect can be increased or decreased by changing cam on the sensing cycle. With shorter cycles, control more nearly approaches straight line. A limit Simplytrol locks up when the trip point is reached and remains locked until reset. Use limit Simplytrols for monitoring and safety shutoff or alarm.



Cat. No. 4532-MFP, size 5" x 5½" x 8" deep. Range 0/1500°F, 0/800°C. $127.00

Cabinet model for wall mounting or portable shown above. To the right is an MFP Simplytrol for flush mounting in a cabinet or control panel. Several other mountings are shown in Catalog 4-A. Send for your copy. **Assembly Products, Inc., Chesterland 75, Ohio.** Phone (Cleveland, O.) HAmilton 3-4436. (West Coast: Box XX, Palm Springs 75, California. Phone DHS 4-3133.)

Booth 2919, WESCON SHOW, Aug. 20-23, Cow Palace, San Francisco.

the chemical engineer in MARKETING

Robert M. Magness appointed assistant to the manager of heavy chemicals sales for U. S. Industrial Chemicals Co. Magness comes to U.S.I. from Chemical Construction Corp. where he was a sales engineer on sulfuric acid and phosphate plants.

Rodney Hunt Machine Co., Orange, Mass., names **Howard B. Smith** as sales engineer in the Middle Atlantic Area for their Process Equipment Division. Smith was formerly process design engineer with United Engineers and Constructors, Philadelphia.



Smith

New member of the Sales Engineering Staff of A&P. Finishing and Manufacturing Co. is **James A. Liontas.**

Blaw-Knox announces promotion of **Charles G. Strowe** to manager of the Central District of the company's Chemical Plants Division.



Strowe

Elmer C. Mertz named supervisor of pyro-processing machinery sales at Allis-Chalmers Manufacturing Co. Mertz has been associated with Allis-Chalmers since 1945.

Homer S. Myers has been elected to fill the newly-created post of vice-president for marketing for Tracerlab, Inc. Myers was previously general manager of the firm's Industrial Division.



Myers

Necrology

William B. Gery, 60, director, Indus. Tech. Div., Dorr-Oliver Inc., Stamford, Conn.

Charles J. Smith, Jr., 41, chemical engineer, Olin-Mathieson Chemical Corp.

Harry Stanley Rogers, 66, president of Polytechnic Institute of Brooklyn.

INDEX

	Page
Abbé, Inc., Paul O.	88
Ace Glass Incorporated	134
Adams Company, Inc., R. P.	133
Adsco Div., Yuba Industries, Inc.	73
Air Products, Inc.	28
Aldrich Pump Co., The	123
Allis-Chalmers	45, 139
American Agile Corp.	137
Amersil Co., Inc.	136
Annin Div. of The Annin Corp.	125
Armstrong Co., Richard M.	120
Artisan Metal Products, Inc.	144
Assembly Products, Inc.	154
Autoclave Engineers	81
Ayerst Laboratories	130
Babbitt Steam Specialty Co.	126
Babcock & Wilcox Co.	9
Badger Mfg. Co.	63
Baker Perkins, Inc.	122
Barco Manufacturing Co.	110
Bart Mfg. Corp.	143
Bin-Dicator Co., The	145
Black, Sivalls & Bryson, Inc.	83
Blaw-Knox Company, Chemical Plants Div.	131
Bowen Engineering, Inc.	69
Cambridge Wire Cloth Co.	114
Carbide & Carbon Chemicals Co. Div. of Union Carbide & Carbon Corp.	Cover 2
Carlson, Inc., G. O.	29
Catalytic Construction Co.	42-43
Centrico, Inc.	115
Chempump Corporation	85
Chicago Bridge & Iron Co.	21
Cole Mfg. Co., R. D.	145
Continental-Emsco Co. Div.	8
Cooper-Bessemer Corp.	79
Crane Company	61
Croll-Reynolds Co., Inc.	15
Croll-Reynolds Eng. Co., Inc.	62
Crosby Valve & Gauge Co.	312
Crossroads Marine Disposal Corp.	155
Crucible Steel Co. of America	13
Davis Sons' Mill Machinery Co., H. C.	154
Davison Chemical Co.	51
Dean Thermo-Panel Coil Div.	155
De Zurik Corporation	37
Dow Chemical Co.	23
Downingtown Iron Works, Inc.	16
Doyle & Roth Mfg. Co., Inc.	84
Duriron Co., Inc., The	55
Eastern Industries, Inc.	96
Eaton-Dikeman Company	98
Eco Engineering Co.	112
Eimco Corporation	135
Falls Industries, Inc.	86
Ficklen III, Joseph B.	132

BUSINESS OPPORTUNITIES

LOUIS NEWMARK LTD., a well known British firm of precision Engineers and instrument makers (London Area) are desirous of entering into a Licence agreement, or purchasing outright, patents relating to electrical and/or mechanical devices of a Precision Instrument character or of a consumer goods nature.

Adequate capital and production facilities are available to develop, produce, and market suitable devices. Communications should be addressed to Louis Newmark Ltd., Purley Way, Croydon, Surrey, England and marked for the attention of Major S. F. M. Neill.

OF ADVERTISERS

	Page
Firestone Plastics Co.	129
Floridin Co.	132
Fluor Corp., Ltd.	91
Fluor Products Co., Div. of the Fluor Corp., Ltd.	50
Foxboro Company, The	47
Frederick Iron & Steel, Inc.	148
General American Transportation Corp., Louisville Drying Machinery Unit	87
Girdler Company, The	
Catalyst Dept.	121
Gas Processes Div.	127
Gordon Co., Claud S.	146
Goslin-Birmingham Mfg. Co. Inc.	148
Graham Manufacturing Co., Inc.	54
Graver Tank & Mfg. Co., Inc.	64
Gump Co., B. F.	3
Harshaw Chemical Co.	6
Hilliard Corp., The	128
Illinois Water Treatment Co.	146
Industrial Filter & Pump Mfg. Co.	147
Ingalls Shipbuilding Corp.	100
Ingersoll-Rand	46, 117
International Nickel Co., Inc.	103
Jet-Vac Corp., The	155
Johns-Manville	10-11, 32-33
Kemp Mfg. Co., C. M.	27
Koven Fabricators, Inc.	119
Lapp Insulator Co., Inc.	113
Lawrence Pumps Inc.	90
Layne & Bowler, Inc., Memphis	17
Layne & Bowler Pump Co.	101
Linde Air Products Co., Div. of Union Carbide & Carbon Corp.	31
Louisville Drying Machinery Unit, General American Transportation Corp.	87
Lummus Co., The	99
Manning & Lewis Engineering Co.	136
Metals Disintegrating Co.	7
Midland Industrial Finishes Co.	56
Milton Roy Company	Cover 3
Mixing Equipment Co., Inc.	Cover 4
Monsanto Chemical Company	48
National Carbon Co., A Div. of Union Carbide & Carbon Corp.	93
National Engineering Co.	34
Newark Wire Cloth Co.	44
Niagara Blower Co.	102
Peerless Pump Div.	71
Permutit Co., The	111
Pfaudler Co., The	89
Pittsburgh Coke & Chemical Co.	97
Posey Iron Works, Inc.	26
Powell Co., The William	53
Process Filters, Inc.	75
Pulverizing Machinery Div., Metals Disintegrating Co., Inc.	7
Renneburg & Sons Co., Edw.	143
Roots-Connersville Blower Div. of Dresser Industries, Inc.	18
Sargent's Sons Corp., C. G.	124
Schutte & Koerting Co.	41, 138
Sel-Rex Corp.	126
Sharples Corp., The	14
Simpson Mix-Muller Div.	34
Sparkler Mfg. Co.	57
Sperry & Co., D. R.	137
Spindler & Sons, Inc., August	109
Spray Engineering Co.	92
Spraying Systems Co.	145
Stephens-Adamson Mfg. Co.	39
Struthers Wells Corporation	104
Sun Shipbuilding & Dry Dock Co.	59
Thermal Research & Eng. Corp.	82
Union Carbide & Carbon Corp.	
Carbide & Carbon Chem. Co.	Cover 2
Linde Air Prods. Co.	31
National Carbon Co.	93
U. S. Electrical Motors, Inc.	142
United States Gasket Co., Plastics Div. of The Garlock Packing Co.	116
U. S. Industrial Chemicals Co., Division of National Distillers & Chemical Corporation	35-36
U. S. Stoneware	108
Vanton Pump & Equipment Corp. Div. of Cooper Alloy Corp.	95
Wallace & Tiernan, Inc.	40
Whitlock Mfg. Co., The	77
Wilmad Glass Company, Inc.	145
Worthington Corporation	24-25
York Co., Inc., Otto H.	4
Yuba Industries, Inc., Adsco Div.	73

WASTE DISPOSAL

- RADIOACTIVE
- EXPLOSIVES
- PYROPHORIC MATERIALS
- POISONOUS GASES
- FLAMMABLE MATERIALS
- CONTAMINATED EQUIPMENT
- TOXIC MATERIALS
- ACIDS AND CAUSTICS

COMPLETE SEA DISPOSAL

Serving the U. S. Since 1946

Truck pick-up for safely removing dangerous waste is provided by Crossroads. Waste can also be shipped conveniently to Crossroads for disposal from any point in the country using the proper type containers shipped in accordance with ICC regulations. Crossroads will supply containers and shipping instructions, if desired.

Authorized by all necessary Federal, State and Local Authorities

Call, write or wire for complete information

Crossroads MARINE DISPOSAL CORPORATION
26 T WHARF, BOSTON, MASS.
LAfayette 3-4908

C.E.P. Advertising Offices

New York 36—Lansing T. Dupree, Adv. Mgr.; John M. Goede, Asst. Adv. Mgr.; Paul A. Jolcuvar, Dist. Mgr.; Donald J. Stroop, Dist. Mgr.; Hale H. Carey, Dist. Mgr.; 25 W. 45th St., Columbus 5-7330.

Chicago 11—Richard R. Quinn, Dist. Mgr., 612 North Michigan Ave., Room 507, Superior 7-0385.

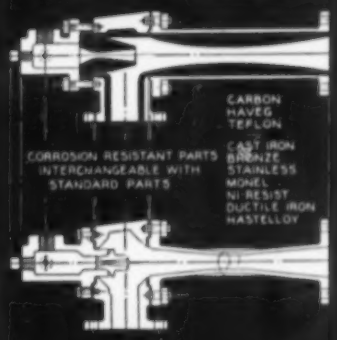
Cleveland 15—Eugene B. Pritchard, Dist. Mgr., 1836 Euclid Ave., Superior 1-3315.

Pasadena 1, Calif.—Richard P. McKey, Dist. Mgr., 465 East Union St., Ryan 1-8779.

Dallas 28—Richard E. Haierman, Dist. Mgr., 2831 El Capitan Drive, Davis 7-3630.

Birmingham 8, Ala.—Fred W. Smith, Dist. Mgr., 1201 Forest View Lane, Vesthaven, Birmingham 9, Ala., TRemont 1-5762.

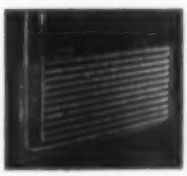
STEAM JET
EJECTORS
CONDENSERS
VACUUM
EQUIPMENT



THE JET-VAC CORP.
73 POND STREET
WALTHAM, MASS.

GOOD BYE to PIPE COILS

Ask for Bulletin 355—52 pages—and learn all about this remarkable Dean creation which TAKES THE PLACE of old style, costly, inefficient, uneconomical pipe coils—for steam or other heating as well as for cooling.



Chemical engineers who once used pipe coils, and who have made a careful comparison, are now specifying the



DEAN THERMO-PANEL COIL

The photo below shows how the Dean Thermo-Panel Coil can be curved for heat for cold) transfer for work that pipe coils can't do.



If you want to do your own designing—or if you want prices—ask for Bulletin 252. And, if desired, Dean specialists will help.

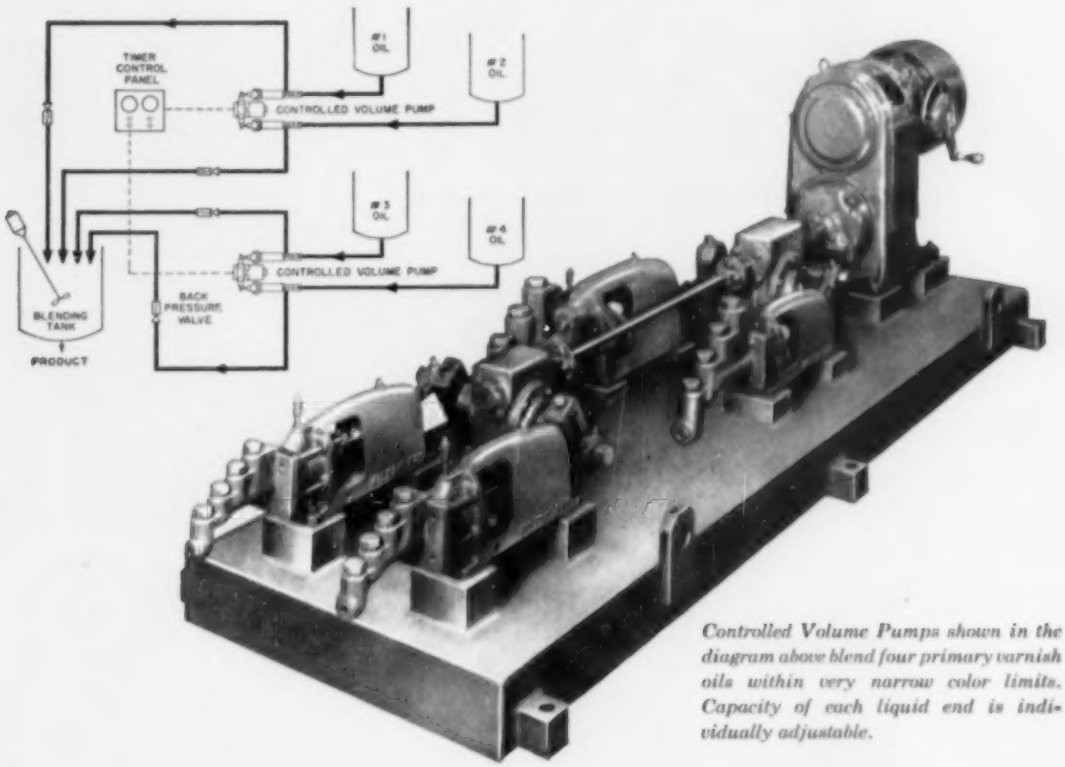
Backed by 20 Years of Panel Coil Mfg.

DEAN THERMO PANEL COIL DIVISION
DEAN PRODUCTS, INC. 615 Franklin Ave.
BROOKLYN 38, N. Y. Tel. Sterling 9-3900

news and notes of A.I.Ch.E.

Continuing last month's committee review . . . **Professional Legislation Committee**, J. P. Cooke, chairman, has a difficult assignment & is at the moment concerned with changes in the various state registration laws . . . A subgroup of the Professional Legislation Committee advises the corresponding E.J.C.-E.C.P.D. committee on these matters & A.I.Ch.E. recently protested an action of E.J.C. in this area, with the result that the action was withdrawn & sent back to committee for study . . . Another activity is a special committee in the New York area studying the implications of certain changes in the New York law as it pertains to corporations. . . . **Program Committee** offers evidence of its activities four times a year to the membership . . . It is responsible for developing all the programs of the A.I.Ch.E. meetings . . . On top of that, this year L. J. Coulthurst, chairman, and E. R. Smoley, vice-chairman, had the Program Committee completely reorganized into different areas of interest . . . The new scheme provides for the orderly progression of a program interest into a division . . . Also working with the Program Committee is a program planning group, which discusses every project before action is taken. . . . **Publications Committee,** under K. N. Kettenring, has been studying the Institute publication policies & making statistical evaluations as a basis for future activities. . . . **Public Relations Committee,** R. L. York, chairman, is involved deeply in every meeting of the Institute . . . It has also been in constant attendance at the Fiftieth Anniversary Committee meetings . . . At a recent meeting of Council the committee prepared an extensive report on the use of a commercial public relations firm by the Institute. . . . **Research Committee** is now under the chairmanship of W. C. Schreiner, Bill Catterall, the chairman at the beginning of the year, having found it necessary to give up this activity . . . This year will see the conclusion of the five-year research program in distillation . . . The committee is currently evaluating the need for research in liquid-liquid extraction. . . . **Sections Activities Committee,** G. E. Holbrook, chairman, is currently in the process of distributing a report on the discussion & talks given at the meeting of Local Section chairmen and vice-chairmen at the Boston meeting last year. . . . **Standards Committee,** under J. C. Lawrence, has a number of balls going in the air at once, being currently involved with the Chemical Industry Advisory Board on many standards, as well as developing a strong committee to work on nuclear standards. . . . **Student Chapters Committee,** Brymer Williams, chairman, is concerned with the health and well-being of Institute chapters, advising on creation of new units & of course every year developing the Student Contest Problem . . . It is also responsible for presenting recommendations of student chapter counselors to Council & for student chapter publications. . . . **Symbols & Nomenclature,** F. M. Tiller, chairman, is currently engaged in a campaign to promote the wider acceptance of the monumental Letter Symbols for Chemical Engineering, published last year . . . In addition, this committee cooperates with the American Standards Association on several committees on standardization. . . . **Should any member want more information** on these activities, a note either directly to the chairman of the committee in question or to the Institute office will be answered promptly. . . . From this outline, one can see the extent & validity of this work & realize that without it the chemical engineering profession would indeed be handicapped. **Mexico City Local Section** of A.I.Ch.E. is close to becoming a reality . . . According to the report by Ricardo Millares, Secretary, the engineers in Mexico City have had a meeting every month since January with attendance running between forty and fifty . . . Cesar Baptista is President & Guillermo Ahumada & Jorge L. Oria were elected Directors . . . Jack Dart's Institute Sections Committee is going to receive any day now from this new group a petition for Local Section status. **Fiftieth Anniversary** to be held June 22 to 27, 1958, will be a tremendous event for American chemical engineering . . . Local arrangements are under Bill Chalfant, chairman . . . The Fiftieth Anniversary Committee planning special events for that week is composed of Past Presidents, with C. G. Kirkbride as chairman & Roy Kinckiner is carrying the ball for the Program Committee. **Student Chapter Counselors:** E. R. Gerhard for the University of Louisville, Nathan Gilbert for the University of Cincinnati, John F. Gorham for the University of Maine, Max S. Peters for the University of Illinois, Charles Walker for Yale University, & Ralph K. Witt for Johns Hopkins University.

F.J.V.A.



Controlled Volume Pumps shown in the diagram above blend four primary varnish oils within very narrow color limits. Capacity of each liquid end is individually adjustable.

Controlled Volume Pumps ratio and blend chemicals exactly...easily...economically

You can be sure of end-product uniformity when you formulate chemicals with Controlled Volume Pumps.

These positive-displacement pumps continuously maintain fixed ratios among all ingredients in a mix. They meter as they pump with an accuracy within ±1%. A single pump can have from three to ten liquid ends.

On the pump shown above, for example, one variable speed motor drives four liquid ends. Capacities differ for all four liquid ends, yet fixed ratios can be established among all capacities. An increase in motor speed produces a corresponding increase in the quantity of chemical metered by each liquid end. The exact ratios of each chemical to another remain constant. Basic ratios can be changed by manual adjustment of stroke lengths on any or all four pumping units.

With capacities ranging to 1350 gallons per hour per liquid end, Milton Roy Controlled Volume Pumps are applicable to both pilot plant and production use. Write for Bulletin 1253, "Controlled Volume Pumps in Process Instrumentation."

MILTON ROY COMPANY, *Manufacturing Engineers*, 1300 East Mermaid Lane, Philadelphia 18, Pa.

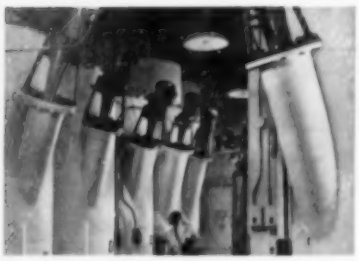
milton Roy
CHEMICAL FEED SYSTEMS

Engineering Representatives in the United States, Canada, Mexico, Europe, Asia, South America, Africa and Australia

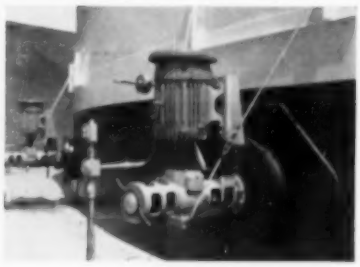


1. GET PRECISE CONTROL of process temperature, heat transfer rate, and product uniformity with turbine-type LIGHTNIN Mixers. Impeller size and speed are carefully selected to give just-right balance of fluid flow and turbulence in any vessel. Hundreds of combinations are available, using standard components. You can get these LIGHTNINs for open or closed tanks, top or bottom entering, in sizes from 1 to 500 HP. For full description, request Catalog B-102.

5 ways to get the right **fluid mixing** *for your process*



2. TANK SHAPE IS NO PROBLEM when you mix fluids with LIGHTNINs. You can get fixed-mounting propeller-type units like these for open tanks or closed pressure vessels. Closed-tank units are installed simply by bolting to the tank nozzle. Direct-drive and gear-drive models; sizes from ¼ to 3 HP. Fully described in Catalog B-103.



3. FOR VERY LARGE TANKS (up to 6 million gallons), you can get high volumetric flow at low cost with a LIGHTNIN Side Entering Mixer. It fits new or old tanks; comes with choice of stuffing box or rotary mechanical seal that's quickly replaceable if it ever wears out. Gear-drive and V-belt drive models, sizes 1 to 25 HP. Described in Catalog B-104.



4. GET RAPID DOUBLE-MIXING ACTION, or gentle thorough stirring, in any open vessel, with a LIGHTNIN Portable Mixer. Direct-drive models for high-speed mixing of thin liquids; gear-drive units for heavier fluids or larger batches. You can get LIGHTNIN Portables, electric or air driven, in sizes from ⅛ to 3 HP. Thirty models. For full description, request Catalog B-108.



5. FOR LABORATORY AND PILOT-PLANT MIXING, you can get as much as 20 years' service from a LIGHTNIN Laboratory Mixer. You can run Model F, shown, at any speed up to 1600 RPM. Four other models to choose from, including one with UL-approved explosion-proof motor for mixing solvents and other volatiles. For description of all five, send for Bulletin B-112.

How to take advantage of what's new in mixing

There are many ways you can use modern fluid mixing to help product quality; increase yield; get better uniformity; speed production.

It takes a specialist to give you full advantage of today's highly developed mixing skills. Your LIGHTNIN Mixer representative can give you this kind of help, because he's backed by *35 years of specialization* in fluid mixing.

For quick, competent assistance on any fluid mixing problem, call him today—or write us direct.

"Lightnin Mixers"

MIXCO fluid mixing specialists

MIXING EQUIPMENT CO., Inc.
199-g Mt. Read Blvd., Rochester 11, N.Y.

In Canada: Greey Mixing Equipment, Ltd.
100 Miranda Ave., Toronto 10, Ont.